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Real-Time Emergency Communication System for HAZMAT Incidents (REaCH) - Phase II

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Real-Time Emergency Communication System for HAZMAT Incidents (REaCH)
Year 2 Report

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The goal of this project to develop a system to help minimize the impact to first responders' health during a transportation related HAZMAT incident. We will develop a dashboard prototype that integrates health and environmental data that is collected using IoT sensors. This data will allow the Incident Commander and Safety Officer to make strategic decisions to protect first responders and transportation workers. The prototype system is called REaCH – Real-Time Emergency Communication System for HAZMAT Incidents. REaCH will include real-time health monitoring of first responders and transportation workers through wearable devices that monitor exposure to hazardous materials.</td></tr>
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Mid-America Transportation Center (MATC)
Nebraska Transportation Center (NTC)
Personal protective equipment (PPE)
Internet of things (IoT)
Real-Time Emergency Communication System for HAZMAT (REaCH)
Hazardous materials (HAZMAT)
Pipeline and Hazardous Materials Safety Administration (PHMSA)
Office of Hazardous Materials Safety (OHMS)
National Fire Protection Association (NFPA)
First responder (FR)
Omaha Fire Department (OFD)

Disclaimer

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Abstract

The goal of this project is to develop an information technology system to help minimize the impact to first responders' health during a transportation related HAZMAT incident. We will develop a dashboard prototype that integrates health and environmental data that is collected and transmitted using Internet of Things (IoT) sensors and technology. This data will allow the Incident Commander and Safety Officer to make strategic decisions to protect first responders and transportation workers. The prototype system is called REaCH – **R**eal-Time **E**mergency **C**ommunication System for **H**AZMAT Incidents. REaCH will include real-time health monitoring of first responders and transportation workers through wearable devices that monitor exposure to hazardous materials. A user interface that presents a dashboard prototype with the integrated sensor data is the planned outcome. This is a multi-year project. This report presents the activities in the second year.

Chapter 1 Introduction

1.1 Organization of the Report

In this document we report on the second year activities for the REaCH - Real-Time Emergency Communication System for HAZMAT Incidents project. This report begins with background on the HAZMAT transportation domain in the context of this project. Next, we describe the goal of our project. To provide background on the project, we report on the activities and research conducted in the first year including 1) interviews with Nebraska transportation professionals, first responders, and key stakeholders, 2) focus group findings, 3) a review of current biosensor and wearable technologies, and 4) requirements for an integrated sensor dashboard design.

Subsequently, we report on the activities and research conducted in the second year including: 1) First Responders' Wearable Technology Survey Results,, 2) progress made towards developing the REaCH IT System and the associated artifacts 3) environmental scan, 4) predictive measures for biomarkers, 5) REaCH health thresholds analysis, and 6) other notable activities.

1.2 Background from year 1

According to the U.S. DOT Pipeline and Hazardous Materials Safety Administration (PHMSA), Office of Hazardous Materials Safety (OHMS), hazardous materials traffic in the U.S. now exceeds 800,000 shipments per day (Lasisi, 2012) and results in more than 3.1 billion tons of hazardous materials annually (The Office of Hazardous Materials Safety Research and Special Programs Administration). Approximately 300 million shipments of hazardous materials are transported annually within the United States. Out of these, 94% of the HAZMAT shipments are moved by trucks (Lasisi, 2012). Between 2007 and 2016, there were 144,002 HAZMAT incidents on US highways, with damage totaling nearly $600M (Office of the Federal Register National Archives and Records Administration, 2011). The top two incident types in the past three years involved flammable-combustible liquids and corrosive materials.

The sensitivity and risks of HAZMAT shipment transportation requires a collaborative framework with technology that enables reliable and cost-effective means to communicate and exchange data during incidents. Today, individual companies track and monitor the status of their trucks and drivers using a range of Intelligent Transportation Systems in the Internet of Vehicles.

Transporting hazardous materials safely, establishing requirements for real-time emergency response information, and monitoring human exposure from hazardous material incidents are national concerns. These concerns are documented in the Fixing America's Surface Transportation Act, or "FAST Act." President Obama signed into law on December 4, 2015.

Past research reports from transportation companies lack real-time monitoring of their drivers transporting hazardous materials. In some cases, the status of hazardous materials is not being measured, and thus potential risks are difficult to identify and are not reported in a timely manner to drivers. Should a hazardous material incident occur the condition of the drivers' and first responders' exposure needs to be monitored closely. This could be made possible via wearable devices that have sensory technology.

A recent study reported that it was difficult for an "Emergency Response Coordination Center" to obtain basic information (e.g., name, nature, and quality of the hazardous materials, etc.) and real-time information (e.g., the location of an accident, the severity level of an accident, etc.) of vehicles, drivers, and hazardous materials during transportation (Ma et. al, 2014). In the first year of our study we conducted focus groups to further assess the current situation in Nebraska.

During such HAZMAT emergencies, first responders are the first to reach the incident site. A first responder is an individual who would immediately be present at the scene during a HAZMAT emergency. They include the fire department, police department, emergency medical services and the department of environmental quality. Over the last few years, there has been an increase in the number of deaths of first responders mainly due to cardiac arrest, heat stroke, stress, lack of oxygen in the blood, and inhalation of hazardous chemicals. National Fire Protection Association (NFPA) statistics reveals the following (National Fire Protection Association, 2017):

- There were more than 30,000 firefighter injuries between 2010-2016
- 42% of fatalities were caused due to physical stress and overexertion
- First responders face a 14 percent increase in cancer-related deaths

1.3 Project Goal

The main goal of our project is to design, develop, and test a technology prototype that will minimize the health impact of first responders when responding to a transportation related HAZMAT incident. Specifically, we plan to create a real-time human and environmental integrated dashboard information system for HAZMAT incident monitoring that could potentially be used in Nebraska and the U.S. The development of the technology prototype follows the agile information system development methodology. For the first phase of our project, we conducted several system requirements gathering activities including a literature review on the background of transportation hazardous material industry, interviews with key stakeholders, focus group with first responders, a review of current sensor technology and prepared a research study on best practices for human health parameters visualizations of data on the dashboard. In the second year, we focused on defining the technical REACH system Information Technology requirements for the new dashboard.

This research project intends to address several issues related to the health of transportation workers and the first responders in the presence of hazardous materials. Our goal is to provide real-time information to decision makers and incident commanders during a HAZMAT incident. Currently, the ability to identify and communicate information on various human health parameters on an integrated user interface platform is limited. Our aim is to develop a prototype that includes wearable sensor devices, mobile apps, and a real-time communication network all first responders and transporters can use during a hazardous materials incident. The new system is called REaCH - Real-Time Emergency Communication System for HAZMAT Incidents.

1.4 Year 1 Activities

- Defining the REaCH system requirements (see Appendix A).
- Interviewing HAZMAT carriers, NE Transportation stakeholders, various units of first responders at Omaha Fire Department.
- Conducting a focus group workshop with HAZMAT first responders.
- Meeting with local hazardous material response teams to identify health monitoring and exposure data needed over a multi-year period for multiple response scenarios.
- A broad review of the current state of wearables for HAZMAT protection, current IoV technology, Intelligent Transportation Systems, and current technology used in the field. Two project team members attend the International HAZMAT and Firefighters conference to learn about the latest technology in the field.

- IRB approval to conduct interviews, focus group workshop with stakeholders and to survey OFD firefighters on their use and attitudes toward health monitoring wearables.

<u>1.5 Year 2 Activities</u>

- Attended and presented at the National Transportation Research Board Annual Meeting, January 2019.
- Met with leaders of the Nebraska Trucking Association.
- Evaluated Internet of Things COTS (commercial-off-the-shelf) sensors and customizable biosensor and environment sensors quality, accuracy, viability, ruggedness, and reliability. Identified the products we plan to field test.
- Continue to identify new and existing wearable and sensory components/features for development and integration into REaCH design.
- Completed several REaCH system requirements artifacts.
    a. Develop and validate REaCH acceptance testing scenarios (e.g. software and hardware requirements).
- Developed a low fidelity integrated user interface and technology platform prototype (REaCH) and prepared for usability study with first responders.
- Completed Environmental Scan.
- Researched Predictive Measures for Biomakers,
- REaCH Thresholds Analysis.
- Report out on the focus group results from year 1.

Chapter 2 Literature Review

2.1 Sensor Technologies

In our project we intend to leverage Internet of Things (IoT) technologies that support human and environmental data capture and transmission through sensors. There are many wearable IoT sensor technologies available that could be utilized in our project. In year 1 we conducted a broad review of the current state of technology. Below we present our findings.

2.1.1 Wearable Technology/Wearable Devices

Wearable Technology/Wearable Devices refers to all electronic technologies that can be incorporated into clothing, accessories, or computing devices that can be comfortably worn on the body. A special feature of wearable devices is that they can provide real time information to their users and some monitor the users' health.

With the latest developments in technology, the Internet of Things (IoT) has paved the way for monitoring healthcare through the evolution of wearable devices built using wearable sensors. The increasing need for self-health monitoring and preventive medicine had given rise to the development of numerous wearable devices, which can be used to monitor health parameters such as body core temperature, heart rate, blood pressure, blood oxygen level, hydration level etc. in various areas. Wearable systems range from microsensors integrated efficiently and effectively into textile materials such as exoskeleton, computerized watches, earplugs, hand gloves, and bracelets to computerized eye glasses such as the Google glass.

Personal Protection Equipment (PPE) are specialized clothing designed for first responders. PPE provides protection from serious injuries and illnesses resulting from contact with chemical, radiological, physical, electrical, and other hazards. Wearing PPE often puts a first responder at considerable risk of developing heat stress. This can result in health effects ranging from heat fatigue to serious illness such as heat stroke and cardiac failure which may cause death. Heat stress is caused by a number of interacting factors, including environmental conditions, clothing, workload, and the individual characteristics of the worker.

First responders are often subjected to working in extreme environmental conditions. The Personal Protection Equipment, Self-Contained Breathing Apparatus and the remaining set of safety gear acts as an extra load on their body, especially under strenuous conditions where the temperature can be extremely dry or extremely wet. One of the main challenges of PPE is the inability to eliminate heat through radiation, convection (transfer of heat through mass motion) and evaporation. The PPE is impermeable in nature which is good from a chemical resistant point of view, but it also prevents the elimination of heat, which results in the lack of heat loss in PPE.

The first responder wearing the PPE will produce his or her own body heat in addition to the temperature conditions outside the PPE. The suit also impedes the wearer's ability to balance the heat production and heat dissipation. This results in the degradation of the effectiveness of the individual i.e. as their core body temperature increases ($T_C > 37°C$), their cardiac output i.e. their heart rate increases.

Temperature and humidity affect the thermal balance of the human body via skin and the respiratory system. So, if there is no scope of evaporation inside the PPE, then the heat dissipated from the first responders' body will have a no way out, thus resulting in the dryness of skin and other harmful conditions which may be fatal. Thus, it is extremely important to monitor the temperature and humidity inside and outside the protection suit of the first responder when subjected to strenuous conditions. Monitoring these parameters can be achieved through biosensors – which are unobtrusive, durable, can be easily worn, and which can be used as an intervention during crisis emergency responses.

The following section gives an overview of the different health monitoring sensors and their functionalities.

2.1.2 Health Monitoring Sensors

2.1.2.1 Telemetry pill

The telemetry pill is able to measure the core temperature directly because the sensor travels through the Alimentary Canal (Byrne et al., 2006). The size of the telemetry pill is similar to a regular pill capsule. Radio frequencies are emitted by the sensor and sent to an external device that records the signals and displays the core temperature data to the user. The pill itself consists of a temperature sensor, radio transmitter, battery and onboard memory. Memory in the pill is to store temperature values at various intervals. Disadvantages are single time use and it is relatively expensive.

2.1.2.2 Zero Heat-Flux sensor

The zero heat-flux sensors are non-invasive and are placed on the forehead. The zero heat-flux sensor bases its core temperature measurement off the bio heat equations for the head's tissues layers and Fourier's heat equation for the foam layer. The device calculates the core temperature through an iterative warming process of the heating element.

An example is the 3M SpotOn Temperature Monitoring System (SpotOn). It is reported as being an accurate, non-invasive system that measures patients' temperatures with an affordable single-use sensor, and provides consistent temperature monitoring.

2.1.2.3 AliveCor's Kardiaband

The AliveCor's Kardiband is a heart rate monitoring system (KardiaMobile). Kardiaband can capture a medical electrocardiogram in 30 seconds anywhere and anytime. It is used by the world's leading cardiac care medical professionals and patients. It has a battery with an operational time of 200 hours and it is compatible with android and IOS platforms.

2.1.2.4 LilyPad Temperature Sensor

The LilyPad detects temperature changes. The MCP9700 is a small thermistor type temperature sensor. This sensor can output 0.5V at 0 degrees C, 0.75V at 25 C, and 10mV per degree C. The LilyPad converts analog to digital that allows the user to establish the local ambient temperature. It can detect physical touch based on body heat and ambient conditions using a small sensor. The LilyPad is a wearable e-textile technology developed by Leah Buechley and cooperatively designed by Leah and SparkFun. Each LilyPad was creatively designed to have large connecting pads to allow them to be sewn into clothing. Various input, output, power, and sensor boards are available. They are even washable.

2.1.2.5 Hot Dot Alert Patch by OSHA

The Hot Dot Alert Patch is a single-use indicator that can help ALERT users of the potential risk of heat-related illness and potentially prevent heat-related injuries and save lives. The Hot Dot Alert Patch used thermo chromatic (property of a substance to change color due to the changes in temperature) technology. The Hot Dot Alert Patch offers real-time monitor of body temperature changes.

2.1.2.6 Zephyr

The Zephyr H x M BT is the first fitness-tracking device that supports both Android and Windows Phone 8 devices. It combines smart fabric, heart rate sensor technology, movement sensors, and Bluetooth connectivity on a chest strap. It is used to extract heart rate information from patients who need continuous monitoring. Due to its Bluetooth low energy technology, it makes the device highly durable, reliable, accurate and comfortable.

Zephyr consists of machine washable straps, a compression shirt and flame resistant wearable shirts. Zephyr's physiological monitoring module helps capture and transmit physiological data on the wearer via mobile and data networks. It is used to capture ECG, respiration, core body temperature, acceleration, time and location of the wearer.

2.1.2.7 Drager – TCORE

The Drager – TCORE is a non-invasive temperature monitoring system. It employs a dual-sensor heat flux technology, which monitors and calculates the core body temperature accurately and continuously. It requires a simple self-adhesive sensor to be placed on the wearer's head.

2.1.2.8 Polar OH1

The Polar OH1 is an optical heart rate sensor (Polar OH1). This heart rate monitor armband can accurately and consistently capture heart rate using Polar's heart rate algorithm and 6-LED solution. It is Bluetooth enabled and easily compatible with IOS and Android with a battery life of 12 hours.

2.1.2.9 Pulse sensor

The Pulse sensor is used to test the heart rate of the user through an Arduino connection. It displays the user's real time heart rate information through an open source app. The Pulse sensor is a simple optical sensor that works by taking advantage of changes in light scattering as a result of increased blood flow. As the heart beats, the volume of blood in the arteries and veins increases rapidly.

2.1.2.10 Texas Instruments CC2650 Sensortag

The Texas Instruments CC2650 Sensortag is an ultra-low power Bluetooth sensor tag which supports the following sensors: temperature, pressure, humidity, accelerometer, gyroscope and magnetometer. The device comes with a TI Sensortag app available on both IOS and android where the data can be captured in a real time environment and can be stored and visualized on the IBM cloud platform through Internet of Things (IoT) technology.

2.1.2.11 CHASE LifeTech FR

The CHASE LifeTech FR (Nokia)] is a Nokia produced product in collaboration with Kolon, a fashion brand in Korea. The jacket is composed of module sensors, which allows the wearer to access data such as heart rate, body temperature, location and motion. The data is captured in a real time environment and can be visualized using GINA's software management system. This product was designed to increase the safety of the first responders and mitigate risks associated during an emergency response.

2.2 Environmental Scan

In year 2, a master student completed an independent study to explore existing literature on firefighters and their occupational exposures that could be harmful to their health. In particular he focused on special operations firefighter units, commonly known as HAZMAT firefighter units. These HAZMAT firefighter units are a specially trained group that control and clean up different forms of hazardous material spills, leaks, and explosions. Additionally, collecting information on the transportation of hazardous materials was also necessary to fully comprehend the potential for a hazardous material event to occur. He presented the literature review to the team. Another student researched literature on the scientific predictive measures for human biomarkers, specifically: heart rate, blood pressure, oxygen pulse, respiration rate, blood oxygen saturation levels, and recovery time. This information will be used in the design and analysis for the human thresholds algorithms in the REaCH system. Student reports are available upon request.

Chapter 3 Research Approach and Methods

The team employed several research approaches and methods, including requirements gathering and data analysis to understand the needs of the stakeholders in the HAZMAT response field. We conducted interviews and a focus group workshop, and surveyed biosensor, HAZMAT, and first responder health concerns literature. We met with subject matter experts (SMES) in Omaha and around the world at the FDIC International conference in Detroit.

Our project began with defining the REaCH system requirements. Our goal is to move from conceptual technology ideas and visions to building, testing, and evaluating working prototypes in the field with end users. We are following best practices in an iterative development approach known as Agile Development. A flowchart of the Agile Development approach is shown in Appendix A.

We are employing the IT Industry Standards Unified Modeling Techniques (Booch et al., 1998) as part of our analysis efforts. For example, we utilized use case diagrams and user scenarios as our modeling tools. A sample use case diagram and examples of user scenarios are shown in Appendix B. (In year 2, we refined these artifacts.)

3.1 Focus Groups

3.1.1 Omaha Fire Department Special Operations

UNMC Institutional Review Board (IRB) approval was obtained to conduct a systematic process for data collection in a focus group format. Participants were recruited from Omaha Fire Department Station 33 HAZMAT team members with the goal to elicit a consensus on their perceptions of the hazards they encounter and their personal and health concerns due to HAZMAT incidents responses, to better delineate the outcome products for this project. The following represents the procedures for the focus group data collection and the results that were generated. After introductions. Dr. Fruhling, PI, provided an overview of the project, Dr. Medcalf then facilitated the session. First, the participants were given a half sheet of paper and asked to list items in response to the following question: When you are responding to a HAZMAT event, what are the things that you worry about? The participants were asked to list at least ten items. Then each item was transferred to its own Post-it note and participants were asked to place their top 4-5 items on the table. Following questions of clarity on the items on the table, participants were asked to group the notes that were similar. This process was repeated until all notes were on the table and clustered into groups. Participants were then asked to assign a name or theme to each cluster.

The cluster with the most notes (items) was chosen and each note was placed in a row at the top of the table. Participants were asked to begin to create additional Post–it notes that represented “solutions” to any or all the notes (items) on the table. Participants were instructed to think of solutions that were not limited by time, technology or availability of funding. Solution Post-it notes were placed in a column below each original item that derived from the cluster that generated the most concerns. Table 3.1 below represents the clusters of concerns that participants considered when they respond to a HAZMAT event. Thematic areas include: Responder Safety; Training; Risk Assessment; Incident Command; Personal Protective Equipment; Weather and Location; Communication; Hazard/Product Identification; Public Safety and Post Incident Review. Each item under “Concerns” represents an individual note placed by all participants.

Table 3.1 Station 33 – HAZMAT Focus Group for Needs Assessment

Themes	Concerns	Notes
Responder Safety	Safety of responders	Life safety
	Fire fighter accountability	Respondent exposure
	Potential external hazards	Long-term health effects
	Adequate staffing?	Education/awareness of political level
	Exit strategy if things go bad	Taking home to family Incident stabilization/ property conservation
Training	Sufficient training	Previous incident experience
	Proper equipment/tools	
Risk Assessment	Secondary explosions	Bioterrorism
Incident Command	Subject matter expert available?	Will proper procedures be followed by incident commander?
PPE	Adequate PPE/ Proper/correct PPE	Extra resources
	Can't see	Maintenance and equipment
Weather and Location	Exact location of spill/leak; topography	Weather conditions
Communication	Communication to the community	Communication before we get to the scene
	Communication among responders (own unit) and interagency	Information collection and dissemination
Hazard/Product Identification	Stop problem/mitigation/stabilization/isolation	How big is the spill/leak
	Equipment needed for ID/Mitigation	Accurately identify hazard/product
	Accurate information	Mixed products
	Building layout/incident layout	Data gathering
	Equipment working?	How/what will HAZMAT change?
Public Safety	Evacuate vs shelter	Where can HAZMAT go?
	Property conservation	Notify and evacuate potential victims
	How many have been exposed/potential victims?	Safety of citizens/public
Post Incident Review	Interagency results and findings	Lessons learned
	What to do differently next time	What worked/what didn't

The diagram below (fig. 3.1) represents the brainstormed solutions to the items of concern clustered under the thematic area entitled: Responder Safety. White boxes indicate the original concerns from the notes generated by participants. The blue boxes represent the solutions that participants wrote for any or all of the concerns.

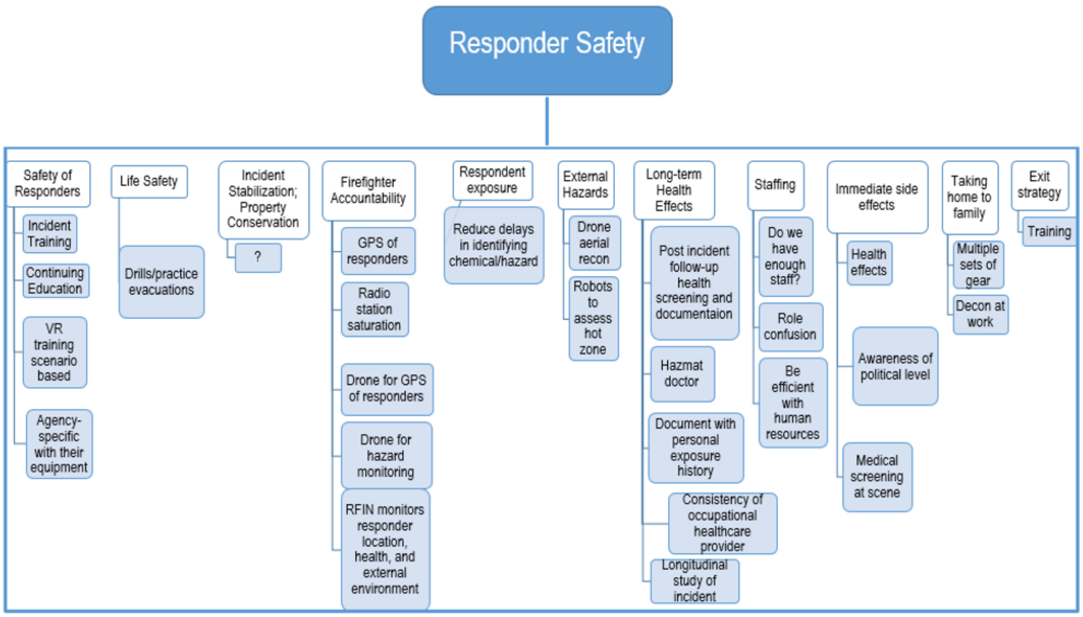

Figure 3.1 Responder Safety Themes and Concerns

3.1.2 HAZMAT Haulers Interviews

In June 2018, Drs. Ann Fruhling and Chandran Achutan met with the CEO of a trucking company in Omaha. The purpose of the meeting was to understand the health and safety concerns of the trucking industry. The company employs between 130 and 140 truckers. They work 14 hours a day; they drive up to 11 hours a day. They are allowed to work 70 hours over 8 days before they have to take 34 hours of rest. This company transports gases such as nitrogen, oxygen, argon, carbon dioxide, hydrogen, helium, hydrogen chloride, ethylene, and carbon monoxide. Potential health and safety hazards include asphyxiation in confined spaces. When the truckers are in refineries, truckers wear oxygen and hydrogen sulfide monitors. Trailers are not washed—they do not change chemicals. They are purged. Sometimes there are fuel spills and oil leaks; truckers usually have PPE on hand. The trucks have satellite devices which monitor speed, truck performance, and sudden stops and starts. Cameras that face inwards and outwards capture driver behavior.

The CEO raised the following health and safety concerns:

- Unknown chemicals at the destination,
- Physical security of truckers from guns,
- Counter terrorism threat as trucks cross across Country land borders, and
- Lack of place to park the trailer at night.

The CEO offered to allow truckers to participate in a focus group with our research team.

Dr. Chandran Achutan also participates at the monthly Safety Meetings at the Omaha Fire Department (OFD). He is a Certified Industrial Hygienist and advises OFD on workplace health and safety policies.

The project team met with Lincoln-Lancaster County Health Department, Ron Eriksen, the faculty in the UNO Emergency Management program, faculty in the Biomechanics program that have expertise in health biosensor research. The team also had numerous interviews with Omaha Fire Department leadership, fire fighters and special operations unit members.

3.2 Integrated Sensor Dashboard Design

A first responder (FR) is an individual who arrives first at a hazardous material incident site and takes the initiative to act in order to minimize the risk to public health and property. Often the FRs are firefighters. Information collected interviews and focus groups above revealed that the FRs may experience severe health related issues due to physical exertion, psychological stress and extreme working conditions. These issues range from thermoregulatory exhaustion and acute dehydration to fatal cardiac arrest, cancer and suicides. Research shows that 39% of FR fatalities are due to heart failure and 61% due to reasons like trauma, burns, etc. (Perroni et al.,2014).

To ensure FRs' safety, the incident commander (IC) monitors critical information about FRs and the incident site. The IC's decision regarding FRs' safe evacuation or withdrawal from the site is dependent on the collected information. The most critical parameters for an IC to monitor during such emergencies are FR's heart rate, core body temperature, available oxygen percentage and environmental air quality.

As part of our goal of this project to develop a Dashboard prototype, a smaller study conducted by a graduate student will focus on most usable display formats to visualize FR critical health and environmental data. In this study, each identified critical parameter will be represented through different design display formats. The designs will be developed iteratively using standard guidelines and feedback from expert UI designers. These designs will be examined in a scenario-based simulated testing environment. The study will follow a mixed-method approach involving qualitative open-ended responses and survey data to evaluate the usability of these designs. In the first year of this project, the study was designed and IRB approval was completed.

3.3 First Responders' Wearable Technology Survey

The First Responders' Wearable Technology Survey was developed in the College of Public Health at the University of Nebraska Medical Center on behalf of the Real-Time Emergency Communication System for HAZMAT Incidents (REaCH) project. The survey was designed to gain more insight into first-responders' use of technology and identify methods that further our understanding of monitoring exposure to hazardous environments.

This information will not only help identify the feasibility of first responders using wearable technology for monitoring real-time diagnostics during environmental incidents, but it will also help determine the viability of using wearable technology for monitoring first responders' health when responding to an incident.

All the information provided will be kept confidential and personal identifying information (email, etc.) will be separated from responses to ensure that no individual can be identified. If first responders would like to be contacted for a follow-up interviews, they voluntarily provide their email address following the completion of the survey. Participation in this survey is voluntary but their participation is critical to help understand first-responder incidents and to develop methods that will prevent workplace injuries.

In the second year, the First Responders' Wearable Technology Survey was sent to a Special Operations Unit of the Omaha Fire Department (n=20). In the second phase of distribution, the entire Omaha Fire Department (n=500) was surveyed.

The survey consisted of six open-ended questions, three dichotomous questions, three multiple-choice, and four multiple response questions for a total of 16 questions. The survey was intended to understand firefighter's views on, 1) the idea of and confidence using wearable technology, 2) which physiological and environmental indicators should be monitored, and 3) who should be responsible for monitoring the health and environment while in the field. Prior to being administered, the survey was approved by the Institutional Review Board (IRB) of the University of Nebraska Medical Center. The survey was distributed to all the Omaha Fire Department stations and then subsequently to all firefighters. The survey could be completed via mobile devices or personal computers using Microsoft Forms. Microsoft Forms is an online survey creator that is available on Office 365 Education, and it allows the creator to develop the survey and collect data from the questions answered. Microsoft Forms was used to format the survey and administer the survey. We used SAS software to analyze the data from the survey. There was no incentive to complete the survey; the participants were fully aware of the survey's purpose and were able to withdraw at any time.

Out of the 645 first responders in the Omaha Fire Department, there were 115 (17%) responses with a mean age of 42 ± 7.2. Out of the 115, 112 stated whether they are part of the special operations group. There are 78 (70%) who are not part of the special operations group, and 34 (30%) who are part of the special operations group.

Among the 113 responses to the question of whether they have ever used wearable technology (i.e., Fitbit, Smartwatch), 53 (47%) selected yes, and 60 (53%) selected no. Amongst the 53 respondents who selected yes, 31 (58%) of the respondents selected that they are currently using wearable technology. Also, 16 of 31 (52%) said they are extremely confident in their ability to operate wearable technology, 11 of 31 (35%) are very confident, 4 of 31 (13%) are somewhat confident, and 0 of 31 for both not so confident, and not at all confident.

Seventy (70) out of 111 (63%) respondents preferred to have their health indicators monitored by both the Personal Accountability System (SEMS) operator and themselves while working in the field. Twenty-eight (28) (25%) preferred to monitor themselves only, and 9 (8%) preferred to have the SEMS operator be solely responsible, and 2 (2%) selected to have neither monitor or listed another preference referred to table 3.2. In answer to which health indicators respondents perceived as important for monitoring, 98.2% preferred their heart rate, 93.8%

preferred their blood pressure, 89.2% indicated core body temperature, 67.6% indicated skin temperature, and 87.3% indicated hydration level monitoring while in the field.

Additionally, 49.1% selected stability, 51.8% preferred falls, and 87.5% selected their breathing rate to be monitored. Sixty-four percent (64.9%) preferred breathing depth, 91.1% chose blood oxygen levels, 86.1% chose respiration carbon dioxide (CO2) levels, 86.6% selected cortisol levels, and 71.8% preferred skin resistance (Stress and Hydration) levels to be monitored while working in the field.

Table 3.2. The frequency of response to question "If someone were to monitor your HEALTH while working in the field, who would you prefer?"

Responses	N
A paramedic dedicated to monitor during the entire incident	1
Designated paramedic or rehab officer. SIMS Operator has other responsibilities and is not always a medic.	1
My SEMS Operator	9
My SEMS Operator and myself	70
Myself	28
Neither, I prefer not to have my health monitored	2

Seventy-one (71) out of 111 (64%) respondents preferred to have environmental indicators monitored by both the SEMS operator and themselves, 18 (16%) preferred the only the SEMS operator to monitor the environment, 16 (14%) chose themselves to monitor solely, 4 (4%) selected another option, and 2 (2%) preferred neither referred to table 3.3. For what to monitor environmentally, 59.8% chose PH, 95.5% chose O2, 100% selected CO, 99.1% preferred H2S, 96.5% chose combustible gas, 78.8% preferred ammonia, 88.5% chose particulates, 87.4% selected CO_2, 71.2% preferred Biological Proteins, and 82.9% chose Radiation to be monitored while in the field.

Additionally, 97.3% selected lower exposure limit (LEL), 90.2% preferred temperature inside the suit, and 82.9% chose the temperature outside the suit to be monitored. 70% selected humidity inside the suit, 69.1% preferred humidity outside the suit, and 53.6% chose noise levels inside the suit to be monitored. 53.2% selected noise levels outside the suit, 98.2% chose hydrogen cyanide (HCN), 83.9% preferred volatile organic compounds (VOCs), and 78.6% selected polyhalogenated compounds (PHCs) to be monitored while working in the field.

Table 3.3 The frequency response to question "If someone were to monitor your ENVIORNMENT while working in the field, who would you prefer?"

Responses	N
A paramedic captain	1
Assistant Safety Officer	1
Battalion Chief	1
My SEMS Operator	18
My SEMS Operator and myself	71
Myself	16
Neither, I prefer not to have my environment monitored	2
somebody assigned by the incident commander	1

There were three open-ended questions regarding why respondents do not use wearable technology, whether there are any additional types of health indicators that should be monitored, and whether there are any other types of environmental hazards that should be monitored. Regarding wearable technology, sixteen respondents commented that current wearable devices are too expensive, and sixteen respondents said there is no need for them to wear them. Five respondents would prefer blood glucose levels to be added as a physiological indicator. One respondent indicated that radon levels should be monitored in all stations, and one commented that wind direction and speed should be added as an environmental indicator to be monitored.

Chapter 4 Other Notable Activities

4.1 Year 1

Two graduate students presented their literature research and research project at the annual UNO Student Research Fair. The posters are presented in Appendix D and Appendix E. Vikas Sahu's poster presentation, "Visualize to Realize: Improving Safety of First Responders." Received the Meritorious Graduate Poster/Demonstration (third place) Award out of 150 student poster presentations. <https://digitalcommons.unomaha.edu/srcaf/2018/schedule/177/>. Graduate student, Chaitra Venkatesan also had a poster presentation called "Testing Environmental Sensors to Reduce Health Ailments among First Responders." Drs. Sharon Medcalf, Aaron Yoder, Chandran Achutan, Matt Hale and Ann Fruhling presented the focus group needs Assessment results to the Engine 33 Special Operations Unit part of the Omaha Fire Department.

Graduate Student Vikas Sahu and Dr. Ann Fruhling presented and published a paper in the proceedings of the Americas Conference for Information Systems (Sahu & Fruhling, 2018a), (Sahu, 2018b). Graduate student Chaitra Venkatesan, Dr. Sharon Medcalf and Dr. Ann Fruhling presented and published a paper in the proceedings of the Americas Conference for Information Systems (Venkatesan et al., 2018a), (Venkatesan et al., 2018b).

As a direct result of the partnership developed between our research team and the Omaha Fire Department, we submitted a research grant related to firefighters, to the Department of Homeland Security (Achutan, PI; Fruhling, Co-PI). The title of the grant was, "Preventing heat-related illnesses in firefighters through integrated sensors." The grant had the following specific aims: 1) Assess participants' work practices, work equipment, and comfort with technology; 2) design a novel, user-friendly way to integrate temperature, relative humidity, and heart rate sensors in firefighter suits; and 3) evaluate the efficacy of the integrated technology in Personal

Protective Equipment (PPE) to mitigate heat-related illnesses. The grant was not funded, but we plan to submit a modified version to the National Institute for Occupational Safety and Health.

4.2 Year 2

Two students graduated in May, 2019. The experience they gained from this project was a game changer for them to receive a job offer. Brian Collett was offered and accepted a position at Valmont. His experience on this project was an important factor in him being offered the position. This is documented on the College of Information Science and Technology website. Another student, Suzy Fendrick was offered an information technology internship at a National Long-Haul company. Graduate Assistant, Vika Suhu completed his thesis, A Comparative Study on Visualization Design Preferences to Monitor First Responders' Health (Sahu, 2019) and was offered a UX position at Mutual of Omaha. Graduate Assistant Jacob Grothe graduated and was an offered a position as an Epidemiologist at the Pottawattamie County Health Department. Their experiences on the project helped them during the interview process and in receiving job offers. Khatri wrote the following note: "Thank you Dr. Fruhling for all your help, support and guidance. It's been a great learning experience for me. I really have learned a lot from Reach and Nebraska Watershed Project. You always gave us the freedom to learn and implement, that really helped me to grow. Good news is "I got a full time job as a Backend Software Developer" at TSG (The Strawhecker Group) in Omaha." His experience on this project definitely was a game changer for him to receive a job offer.

Drs. Medcalf, S., Yoder, A., Fruhling, A. attended the Transportation Research Board (TRB) 99th Annual Meeting in January, 2020. Drs. Medcalf, Yoder, and Fruhling presented a poster titled, “Requirements Gathering through Focus Groups for A Real-Time Emergency Communication System for Hazmat Incidents (Reach)”. Our research area was new to many of the attendees so this introduced them to transportation worker and first responder health and environment safety monitoring perceptions and interests.

Students have learned numerous skills in system development and about the transportation industry and safety. They shared their knowledge at the UNO Student Creative Activities and Research Fair. Student Suzy Fendrick presented a poster titled, “Design for Safety: Decreasing First Responder Health Risk through Real-Time Bio-Sensor Alerts” and student Naveena Akula presented a poster titled, “Lessons Learned from Designing a Health Monitoring System to Improve First Responders Safety User Interface” at the UNO 2019 and 2020 Student Research Fairs (Fendrick and Fruhling, 2019), (Akula, et. Al, 2020). All of the students have benefited from this project on honing and learning new software development processes and procedures.

Dr. Fruhling and Dr. Medcalf participated in the University of Nebraska-Lincoln Transportation Centers External Review from June 17-20, 2019.

Dr. Achutan is researching noise pollution. He has been working with the OFD safety committee and found out that first responders easily get a lot noise pollution from a single event.

We enlisted Tyler Scherr as the Project Monitor. He is a Ph.D. Licensing Associate at UNeMed Corporation, located at 986099 Nebraska Medical Center, Omaha, NE 68198. He can be reached by office phone at 402-559-2140 or email at tyler.scherr@unmc.edu

A paper titled “Designing a Real-time Integrated First Responder Health and Environmental Monitoring Dashboard” was accepted at the DESRIST Design Science Research in Information Systems 2020 conference to be held in December, 2020.

Chapter 5 IT System Development Artifacts

In year 2, we continued working on Reach Requirements and Design Documentation and completed several UML diagramming artifacts: use cases, sequence diagrams, component diagrams, and security elements. We continued the design of threshold user interface and the process of entering thresholds and comparing first responder health biomarkers to thresholds. We completed building the low fidelity REaCH system prototype using Protoshare wireframe software. Five graduate students have contributed to this project: Jackson Urrutia, Naveena Akula, Anusha Manda, Hitesh Khatri, and Jacob Grothe.

We completed research study design including prototypes for three scenarios. We scheduled a comprehensive User Interface evaluation with Stan Shearer OFD and others (Incident Commanders and Medics). This was scheduled for April 6, 2020 via zoom. Stan Shearer became ill with COVID-19 and he had to postpone his involvement. This study has been completed in year 3.

5.1 REaCH IT System Requirements Documentation

The REaCH IT System Requirements Documentation can be found in Appendix E.

5.2 REaCH System User Interface Prototype

The REaCH System User Interface Prototype Documentation can be found in Appendix F.

5.3 REaCH Technical Development Documentation

The REaCH Technical Development Documentation can be found in Appendix G.

Chapter 6 COVID-19

On March 12, 2020 students working in the lab were asked to begin working remotely due to the COVID-19 pandemic. Likewise, some of the faculty on project were asked to work remotely by the University, if possible. One faculty member was pulled from the project to work on the front line to support the Medical Center's preparation and response to COVID-19 and to care for patients.

The estimated impact to the project reduced productivity to around 80% until August, 2020. Students had many distractions, although, they all attended every meeting. One of the co-PIs, Dr. Medcalf was unavailable for meetings due to her job assignments being re-allocated to support front-line support for COVI-19 at UNMC. Dr. Sharon Medcalf, reported, "I think I can safely say that the covid-19 response has derailed me completely from the project." She is on the front-line as the Associate Director, Center for Emergency Preparedness at UNMC. She has been diverted to create online instruction when that is not the norm.

Further, there has been tremendous impact on our students at a time when our project is graduating seasoned students and we need to find replacements who can work remotely. The transfer of knowledge was very challenging. All of these issues impacted our progress, but I expect us to make full recovery and complete the project as planned. Dr. Fruhling's research lab is large enough that three students can work in the lab safely at the same time, although no students have returned to working in the lab. There are two offices with doors and a third space that is isolated. We adjusted our workplan for summer 2020. Four new graduate assistants will start in the Fall and are moving full-speed ahead working remotely. One of them is at the College of Public Health.

Chapter 7 Future Work

In year 3, the project team will continue to develop the REaCh system from a low fidelity prototype to a high fidelity prototype. Further, we will continue the IT (information technology) development of the REaCH Application including test scenarios, test plan and test data, and integrating data analytics approaches to visualize health trends. We will reschedule the comprehensive user interface evaluation with Stan Shearer OFD and others (Incident Commanders and Medics).

We plan to survey stakeholders associated with the Nebraska Trucking Association and conduct focus groups to get feedback on our REaCH system prototype. We also hope to survey first responders (specifically State Patrol personnel) on personal use of wearable technology (e.g. biosensors, fitness trackers) devices similar to a survey we did with first responders at OFD.

We will purchase wearable sensor COTS products and test them for accuracy and assess how well they will integrate with the REaCH system.

Dr. Fruhling will supervise summer Information Technology Innovation undergraduate student (Jordan Biniamow) doing an independent study to learn IoT technology. His assignment is to help develop the user interface of the main page of the dashboard. (No cost to the project; however, a great learning experience for this student.)

We will explore opportunities to work with Dr. Rilett on introductions to tribal native communities with regards to this project.

7.1 UNMC Planning Grant Collaboration

Co-PI Dr. Chandran Achutan is the PI for an internal UNMC grant called, “Integrating wearable sensors in firefighter suits to prevent heat-related illnesses”. This is a new research project that was inspired due to this project. Co-PIs are Dr. Ann Fruhling, Dr. Aaron Yoder, Dr.

Elizabeth Lyden, and Dr. Sharon Medcalf. The aim of this adjoining project is to develop, implement, and evaluate a novel integrated sensor in Personal Protective Equipment (PPE) strategy to prevent heat-related illnesses, a known risk factor for cardiovascular disease. The start date of this project was delayed due to COVID-19.

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N. Akula[1], J. Urrutia[1], H. Khatri[1], M. Anusha[1] , J. Grothe[2], S. Medcalf[2], A. Yoder[2], D. Ghersi[1], C. Achuthan[2], A. Fruhling[1] University of Nebraska at Omaha[1], University of Nebraska Medical Center[2], Lessons Learned from Designing a Health Monitoring System to Improve First Responders Safety User Interface, Poster Presentation, UNO annual Student Activity and Research Fair, March 6, 2020. Student N. Akula presented.

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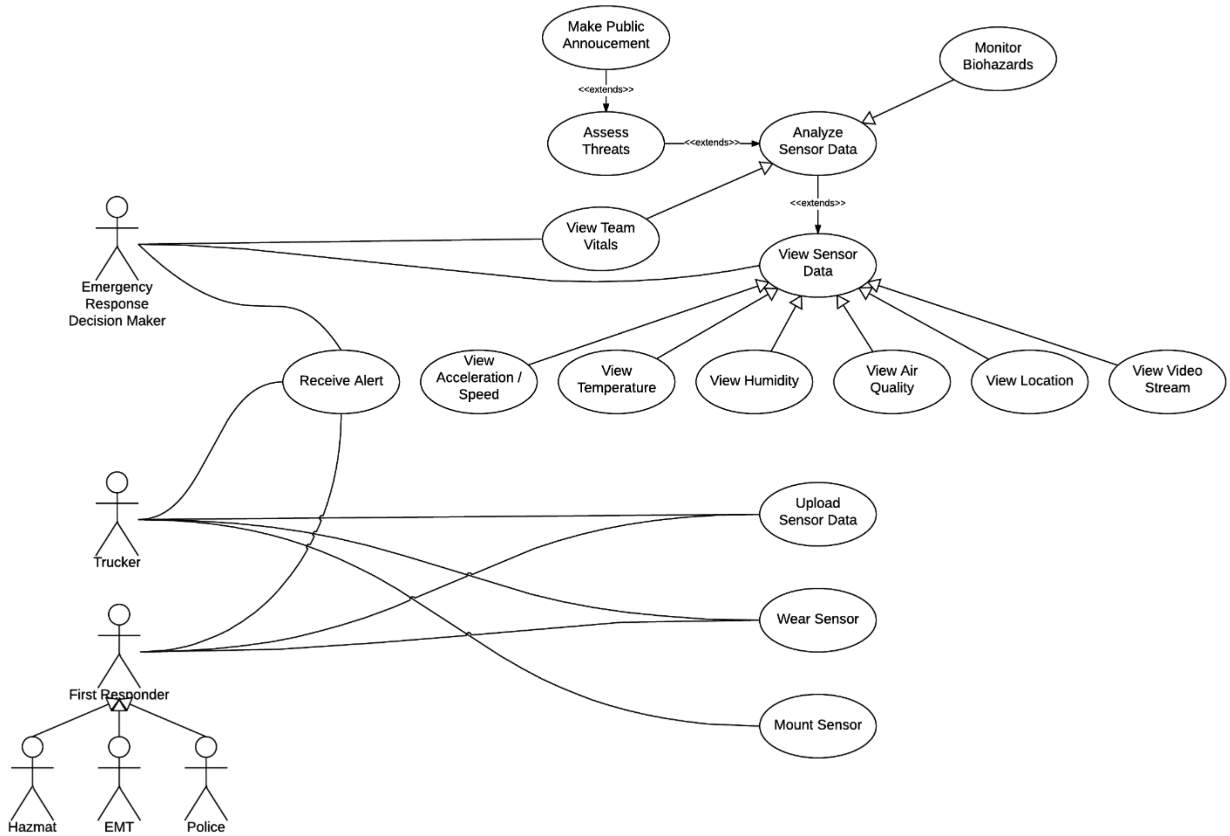
Appendix A Sample User Diagram and User Scenarios



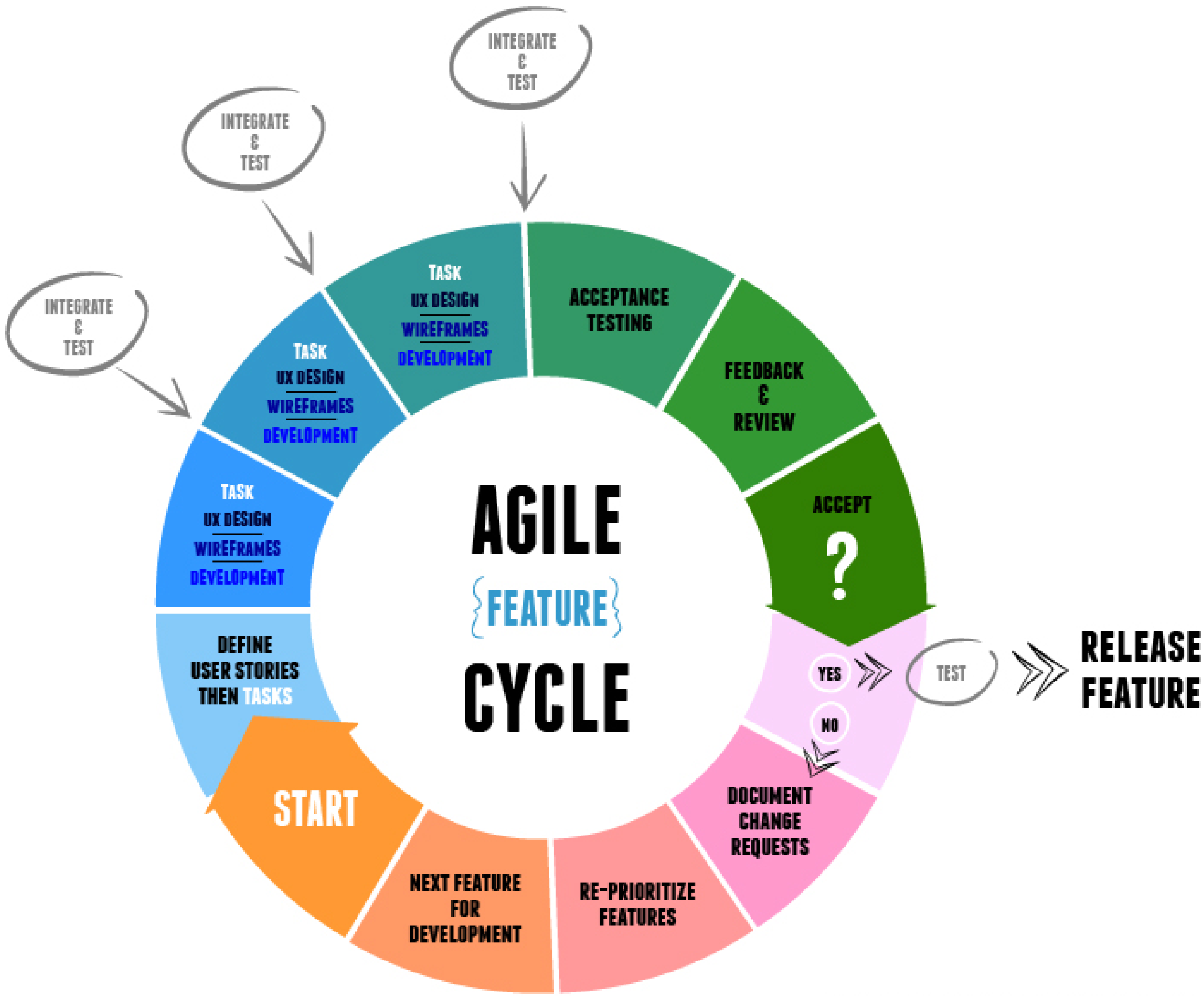
Backlog

1. As a researcher, I must know when the device is powered on and off, so that I know that I can record my participant's data.
2. As a researcher, I need to know that the dashboard is displaying sensor data, so I know that device is transmitting data and the dashboard is receiving data.
3. As a researcher, I need to be notified about a transmission error with the sensor, so I know that I can troubleshoot (this needs to be further defined).
4. As a HAZMAT captain, I want to read data from smart devices, so that I can more accurately identify hazards.
5. As a HAZMAT captain, I want to read data from smart devise, so that I can more rapidly identify hazards.
6. As a HAZMAT tech, I want to monitor the health of individuals on my team, so that I can extricate them from dangerous situations.
7. As a HAZMAT tech, I want to keep track of my team, so that I can strategically deploy resources.

8. As a HAZMAT captain, I want to communicate with corporate entities, so that I can more rapidly identify hazards.
9. As a HAZMAT first responder, I want to receive alerts if my vitals are at abnormal levels, so that I can avoid the area to maintain my health and safety.
10. As a HAZMAT first responder, I want to be able to identify hazards quickly, so that I can better adapt to and mitigate the situation.
11. As a researcher, I want to be able to jump to a particular date/time in the dataset, so I can quickly go to a particular section of data.
12. As a researcher, I want to be able to customize the dashboard, so I can select, view and organize specific datasets.
13. As a researcher, I want to be able to see the information in moveable panes, so that I can focus on just the information I want.
14. As a designer/researcher, I want the information to be color blind accessible, so that a wider range of people are able to effectively use the interface.
15. As a researcher, I want to see data organized by participant, group, or other attributes, so that I can compare the data and do analyses.
16. As a researcher I need to login to the dashboard so that the data is protected.
17. As a researcher I need to be able to select which function I want to do (e.g. view data, connect sensors, etc.)
18. As a researcher I need to be able select the sensor(s) I want to connect for transmission so that data is being captured.
19. As a sensor I need to have day and time included in the data that is transmitted so that the researcher can group the data and a particular participant can be identified.
20. As a researcher I need to be able to assign a sensor to a participant so that I have the association of a participant.
21. As a researcher I need be able to add an event as a marker on the current data so I can go back and do further analysis.
22. As a researcher I need to have the EPOCH data converted to the local time zone since it is collected in GMT time so that the time and data matches the local time zone.
23. As a HAZMAT first responder, I want to read data from smart devices, so that I can more accurately identify hazards.
24. As a HAZMAT captain, I want to keep track of my team, so that I can strategically deploy resources.
25. As a HAZMAT captain, I want to keep track of my team, so that I can help them avoid hazards.
26. As a HAZMAT captain, I want to monitor the health of individuals of on my team, so that I can track longitudinal health and safety.
27. As a HAZMAT first responder, I want to be able to identify hazards accurately, so that I can better adapt to and mitigate the situation.

28. As a HAZMAT captain, I want to monitor the health of individuals on my team, so that I can extricate them from dangerous situations.
29. As a HAZMAT captain, I want to identify hazards quickly, so that I can strategically deploy and initiate the correct resources to mitigate them.
30. As a HAZMAT first responder, I want to read data from smart devices, so that I can more rapidly identify hazards.
31. As a HAZMAT captain, I want to keep track of my team, so that I can help them if they are in distress.
32. As a HAZMAT first responder, I want to keep track of my teammates, so that I can help them if they are in distress.
33. As an admin, I want to be able to assign a sensor to a user during the setup process, so that I know where their data is coming from.
34. As a HAZMAT tech, I want to keep track of my team, so that I can help them avoid hazards.
35. As a HAZMAT tech, I want to keep track of my team, so that I can help them if they are in distress.

Appendix B Agile Methods Flowchart



Agile Feature Cycle by ChromeMedia Inc.

Agile development utilizes a *feature* centric approach that guides the definition and realization of *user stories*. User stories are, as the name implies, short descriptions of the kinds of activities a user is involved in relation to the software. User stories are structured and define the type of *user involved*, the *action* they want to take, and the *goal(s)* of the action as they relate to the user. This structure forms the basis of a software requirement that is implemented as a feature. Feature development is not monolithic, so as user stories are defined, their realization (or achievement) is decomposed into a set of synchronous or asynchronous tasks. Once the tasks are completed, they produce code artifacts that are then integrated together, tested, reviewed, and either accepted or not. If a feature is accepted, then development proceeds onward to the next user story. If not, new tasks are created to realize the story, the story is changed given lessons learned, or the development team re-focuses on other important features needed for the final product. Ultimately, when the core user stories related to a feature are realized, the feature can be released. Often feature releases are grouped together into a new overall product version.

Appendix C Survey

2

Are you part of Special Operations?

- Yes
- No

3

What year were you born? (YYYY)

Please enter a number less than or equal to 2000

4

Have you ever used wearable technology (Fitbit, Smart Watch, etc.)?

- Yes
- No

5

Do you currently use wearable technology?

- Yes
- No

6

Why don't you use wearable technology?

Enter your answer

7

How confident are you in your ability to operate wearable technology?

- Extremely confident
- Very confident
- Somewhat confident
- Not so confident
- Not at all confident

8

If someone were to monitor your HEALTH while working in the field, who would you prefer?

- Myself
- My SIMS Operator
- My SIMS Operator and myself
- Neither, I prefer not to have my health monitored
- Other

9

In your opinion, what types of HEALTH information would be useful to monitor for first responder safety when working in the field.

	Yes	No	Don't Know
Heart Rate			
Blood Pressure			
Core Body Temperature			
Skin Temperature			
Hydration Level			

10

In your opinion, what types of HEALTH information would be useful to monitor for first responder safety when working in the field.

	Yes	No	Don't Know
Stability	○	○	○
Falls	○	○	○
Breathing Rate	○	○	○
Breathing Depth	○	○	○
Blood Oxygen Levels	○	○	○
Respiration CO2 Levels	○	○	○
Cortisol Levels (Stress)	○	○	○
Skin Resistance (Stress and Hydration)	○	○	○

11

In your opinion, are there any additional types of HEALTH information that would be useful to monitor for first responder safety. If so, please list below.

Enter your answer

12

If someone were to monitor your ENVIRONMENT while working in the field, who would you prefer?

- ○ Myself
- ○ My SIMS Operator
- ○ My SIMS Operator and myself
- ○ Neither, I prefer not to have my environment monitored
- ○ Other

13

In your opinion, what types of ENVIRONMENTAL information would be useful to monitor for first responder safety.

	Yes	No	Don't Know
PH	○	○	○
Oxygen	○	○	○
Carbon Monoxide	○	○	○
Hydrogen Sulfide	○	○	○
Combustible Gases	○	○	○
Ammonia	○	○	○
Particulates	○	○	○
Carbon Dioxide	○	○	○
Biological Proteins	○	○	○
Radiation	○	○	○

14

In your opinion, what types of ENVIRONMENTAL information would be useful to monitor for first responder safety.

	Yes	No	Don't Know
LEL - Lower Explosive Limit	○	○	○
Temp (inside suit)	○	○	○
Temp (outside suit)	○	○	○
Humidity (inside suit)	○	○	○
Humidity (outside suit)	○	○	○
Noise - Sound Level (inside suit)	○	○	○
Noise - Sound Level (outside suit)	○	○	○
Hydrogen Cyanide	○	○	○
VOCs - Volatile Organic Compounds	○	○	○
PHCs - Polyhalogenated Compounds	○	○	○

15

In your opinion, are there any additional types of ENVIRONMENTAL i
be useful to monitor for first responder safety. If so, please list below

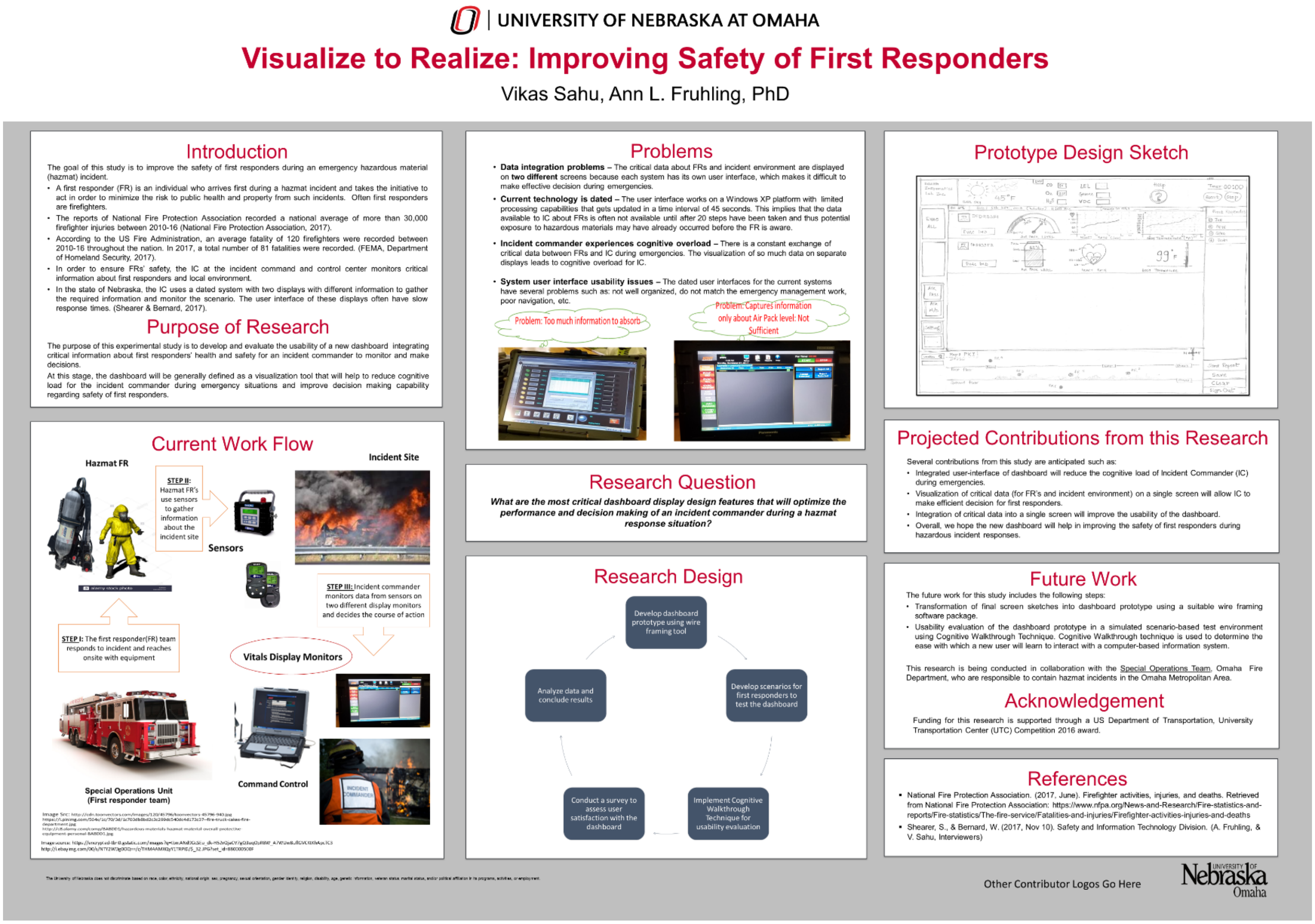
Enter your answer

16

Questions, Comments, and/or Concerns?

Enter your answer

Appendix D Posters



REQUIREMENTS GATHERING THROUGH FOCUS GROUPS FOR A REAL-TIME EMERGENCY COMMUNICATION SYSTEM FOR HAZMAT INCIDENTS (REaCH)

University of Nebraska Medical Center

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ABSTRACT

During HAZMAT emergencies, first responders are the first to reach the incident site. Over the years, there has been an increase in the number of first responder deaths and heat related illness (HRI). HRI are most often studied in outdoor workers and wild land firefighters but occur in a variety of workers across the US. Surveillance programs reported approximately 28,000 HRI hospitalizations between 2001 and 2010. The progression from heat exhaustion to heat stroke can occur rapidly so first responders need warning systems to alert them to the impending health hazards of heat stress. This study works with HAZMAT first responders in Nebraska to explore and assess the current status of responder safety in the state and begins with the first responder focus group requirements gathering process. A consensus building process was used for the focus group sessions and yielded thematic areas of health and safety concern. Responder safety was named the most common area of concern and solutions to individual risks were proposed by focus group participants from a local HAZMAT response team. The results of this focus group serve to inform researchers of priorities to consider in the development of responder health monitoring systems and to continue with research in wearable technology for real time health monitoring. Early intervention when monitored responders demonstrate signs of distress ultimately saves lives.

INTRODUCTION

Approximately 100 firefighters die in the line of duty each year and the leading cause is a sudden cardiac event (Smith et al., 2008). Experts have long known that excessive heat emergencies can lead to cardiac events. Heat related Illness (HRI) are most often studied in outdoor workers and wild land firefighters but occur in a variety of workers across the US. In fact, CDC's Environmental Public Health Tracking program reported approximately 28,000 HRI hospitalizations between 2001 and 2010 (Arbury et al., 2014). The 2016 NIOSH Criteria of Recommended Standard: Occupational Exposure to Heat and Hot Environments recommends that employers establish a medical monitoring system, in an attempt to identify signs of heat related illness and predict and prevent low-term adverse outcomes. Current research is limited to outdoor workers and wild land firefighters, excluding other members of the HAZMAT team including first responders, police officers, emergency medical service personnel, and environmental quality professionals. Our work with HAZMAT first responders in Nebraska explores and assesses the current status of responder safety in the state. While the broader goals of our project center on designing, developing, and testing an integrated technology prototype for safety monitoring and minimizing first responder health impacts during response scenarios, the focus of this paper is report on the data we have gathered through our focus groups that address the status of Nebraska HAZMAT response.

METHODS

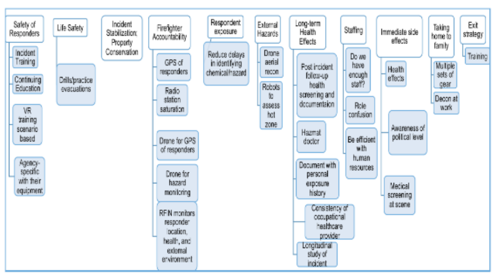
Members of a HAZMAT team in Omaha, Nebraska were asked to volunteer to participate in a focus group following study approval by the Institutional Review Board (IRB) for the University of Nebraska. Eight participants were present and were asked the following question: "When you are responding to a HAZMAT event, what are the things that you worry about?" Participants were then asked to make an individual list of 10 items of concern. Each item was transcribed to an individual card and placed on a workspace visible to all participants. Participants were then asked to cluster the cards that were similar, or represented a common theme. Once clustering was completed, participants were asked to create a thematic name for each cluster. Individual cards were then removed but thematic headings remained visible. Participants were asked to brainstorm possible solutions to any concerns that would be classified under the thematic areas, and place those solutions on individual cards under the appropriate heading.

RESULTS

The table below shows the individual concerns (problems) listed by all focus group participants that are clustered into thematic areas

Themes	Problems	
Responder Safety	• Safety of responders • Fire fighter accountability • Potential external hazards • Adequate staffing? • Exit strategy if things go bad	• Life safety • Respondent exposure • Long-term health effects • Education/awareness of political level • Taking home to family • Incident stabilization/property conservation
Training	• Sufficient training • Proper equipment/tools	• Previous incident experience
Risk Assessment	• Secondary explosions	• Bioterrorism
Incident Command	• Subject matter expert available?	• Will proper procedures be followed by incident commander?
PPE	• Adequate PPE/ Proper/correct PPE • Can't see	• Extra resources • Maintenance and equipment
Weather and Location	• Exact location of spill/leak; topography	• Weather conditions
Communication	• Communication to the community • Communication among responders (own unit) and interagency	• Communication before we get to the scene • Information collection and dissemination
Hazard/Product Identification	• Stop problem/mitigation/stabilization/isolation • Equipment needed for ID/Mitigation • Accurate information • Building layout/incident layout • Equipment working?	• How big is the spill/leak • Accurately identify hazard/product • Mixed products • Data gathering • How/what will Hazmat change?
Public Safety	• Evacuate vs shelter • Property conservation • How many have been exposed/potential victims?	• Where can Hazmat go? • Notify and evacuate potential victims • Safety of citizens/public
Post Incident Review	• Interagency results and findings • What to do differently next time	• Lessons learned • What worked/what didn't

The figure below shows the brainstormed solutions (blue boxes) to the concerns (white boxes) from the thematic area termed "Responder Safety" (above)



DISCUSSION

- The focus group participants seemed to attribute some safety concerns with lack of training and suggested increased training, drills and exercises to address these gaps.
- Ascertaining the exact location of responders in a chaotic response was also listed as a concern of the focus group participants.
- Short-term and long-term health effects from exposure to hazardous materials are common concerns for the participants of this focus group and were reflected in the solutions gathering phase.

CONCLUSION & FUTURE DIRECTION

The results of this focus group serve to inform researchers of priorities to consider in the development of responder health monitoring systems and to continue with our research in wearable technology for real time health monitoring. Early intervention when monitored responders demonstrate signs of distress ultimately saves lives in short-term, but also provides data that can be analyzed over the long-term. In the absence of resource intensive health monitoring by practitioners, wearable sensors may be the answer to systematic health monitoring of first responders and early warning to scene commanders for intervention strategies. The future of responder health and safety using sensors should be explored as a solution to reported adverse events and responder concerns. Wearable technology and sound user interface technology for monitoring may be the future solution for today's gaps in responder health surveillance.

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UNIVERSITY OF NEBRASKA AT OMAHA

Design for Safety: Decreasing First Responder Health Risks Through Real-Time Bio-Sensor Alerts

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Introduction

The focus of this research project is using the Design Thinking process to create an informative dashboard for first responders. Design Thinking involves empathizing with the user, defining the problems to be solved, ideation, creating prototypes, and testing. This iterate process focuses on the user, resulting in the most effective product possible. The dashboard will display real-time biosensor data from sensors in the first responders' uniforms. This project is part of a larger project with the goal of vastly improving the safety of first responders during emergency hazardous material incidents. This project is funded by U.S. Department of Transportation.

Design Thinking Process

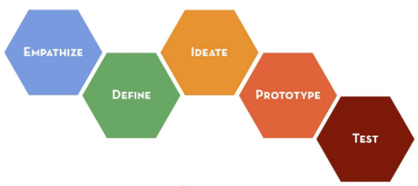

Figure 1

The Design Thinking Process is an iterative process for creative problem solving, as displayed in Figure 1. [1,2]

- Empathize: getting to know who the user is, learning and researching their needs.
- Define: begin analyzation of research and define a problem statement. The problem statement is written from the prospective of the user, not yourself or the company.
- Ideate: brainstorming, coming up with as many solutions to the problem as possible.
- Prototype: narrow down the best possible solution for the problem and defining how it will work.
- Test: see how the potential user will interact with the product created, identifies problems in the design, and what needs to be altered.

Benefits of the Design Thinking Process

- Usability problems found early
- Takes less time, improvements are made early
- Saves money, improvements are made when work is cheap to produce

Empathize and Define

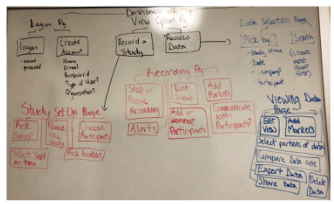

Figure 2

The first step of the process is Empathize. This involved researching current first responder technology, emergency response dashboards and iconography, and communication with local firefighters. After researching, the Define process began. Displayed here in Figure 2 is a map of all the potential web pages needed for the dashboard. The needs of the user need to be defined before designing.

Ideate and Low-Fidelity Prototype

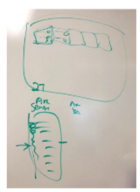

Figure 3

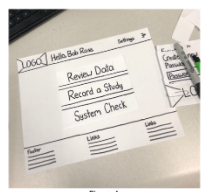

Figure 4

After defining the problem and the user's needs, the ideation process can begin. Ideate involved making simple designs on a whiteboard as displayed in Figure 3. Many ideas were sketched on the whiteboard before moving to Prototype phase displayed in Figure 4. These paper prototypes are low-fidelity and the first step in the prototyping process. They underwent critiques with the HazMat team to alter the design until it was solidified. After making paper prototypes, the next step was creating high-fidelity prototypes and prepare for testing.

High-Fidelity Prototype

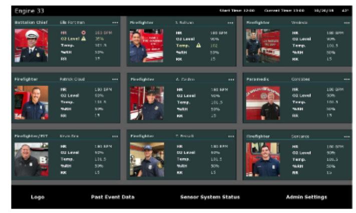

Figure 5

After creating low-fidelity paper prototypes, high fidelity prototypes were created, as seen in Figure 5. They were made on the computer to seem more real and are easier to test on the user. Preparation for the Test phase has begun. So far, these high fidelity mock-ups have been tested out in once with the firefighter leads.

Next Steps and Assessment

The next steps in this research would be:

- Completing all design work and mockups
- Completing all development work of the actual website
- Testing all work with real users

An assessment of the effectiveness of the Design Thinking Process would be the conclusion of this project. This would validate if the system met the user's needs.

References and Acknowledgements

I would like to acknowledge the U.S. Department of Transportation, Region VII Grant: UTC 25-1121-0005-110 for funding my research.

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UNIVERSITY OF NEBRASKA AT OMAHA

Lessons Learned from Designing a Health Monitoring System to Improve First Responders Safety User Interface

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Introduction

Every day, first responders put their own lives at risk to help individuals, families, and communities. They experience many safety and health hazards on the frontline that can lead to injuries, chronic illnesses, and even death. Chronic illnesses include cancer, heart diseases, and behavioral health issues that often cause first responders life expectancy to be significantly shortened.

According to the National Fire Protection Association, there were 64 on-duty firefighter deaths in 2018. Sudden cardiac death accounted for about 40% of the on-duty fatalities. During 2017, there were an estimated 44,530 documented exposures to hazardous conditions (e.g. chemicals, fumes, radioactive materials) and 15,430 collisions involving fire department emergency vehicles responding to or returning from incidents.

To help minimize the health impact of first responders, the overarching goal of the **University of Nebraska at Omaha - Mid America Transportation Center - Department of Transportation (UNO MATC DOT)** research project is to build a health and environment monitoring system that can be used during a hazardous material exposure. The system aims to improve first responders' safety by integrating bio and environmental sensor data and employing decision support technology to send alerts when a first responders' health is at risk. Sensors are useful to monitor the activities and track the individual's health vitals such as heart rate, heat index, respiratory rate, blood oxygen saturation levels, and blood pressure. Through the monitoring of health vitals, an incident commander or medic can take immediate action to remove a first responder from the front-line to minimize long-term health issues when their vitals reach certain thresholds. This poster presents the lessons learned while participating in the design of the user interface and analyzing what technology to use for development. .

The primary goal of the REaCH System dashboard is to build a health and environment monitoring system for improving the first responder's safety during an HAZMAT (hazardous material) incidents.

Overview of REaCH System

In the REaCH System, mainly we have concentrated on hazmat first responders health and safety. First responders need a tablet- or smartphone-based dashboard showing the status of sensors worn by first responders or sensors connected to the equipment they use. Multiple technological solutions (sensors) exist in both the public safety and consumer markets today to monitor the health of first responders and to monitor their activities and equipment. The primary goal of this research is to track the individual's health vitals. Since, health data are useful to get insights about the individual's vitals. Below are the health vitals which we considered in this design

- Heart rate(HR),
- Ambient Heat Index (HI)
- Respiratory Rate (RR)
- Blood Oxygen Saturation Levels (SPO2)
- Blood Pressure (BP)

Research Question

What are the best user interface practices to design a emergency health monitoring system for first responders?

REaCH System Design

Below are the few important displays in the health monitoring system which gives the information about the first responder health vitals and which team are they in use. Also, the threshold value ranges for all different health vitals.

Figure1:- The main dashboard contains the information of the first responders who are in the HAZMAT event, and their health vitals (HR, BP, RR,SPO2).

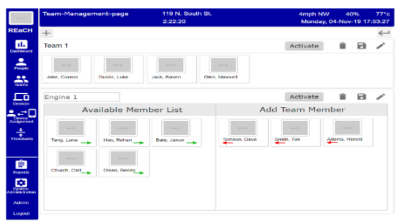

Figure 2:- Teams Page- Assigning first responders to specific teams

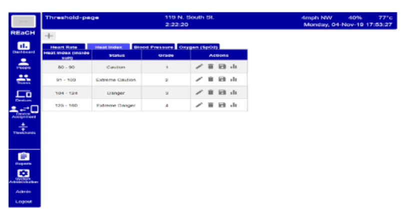

Figure 3:- Threshold's page- Collecting all the health vitals (HR,RR,BP,SPO2) ranges and assigning a grade to each health vital parameter.

Lessons Learned

While designing this REaCH System we focused more several important design practices:

- **Concentrate on User Experience-** We discussed the process when the users open the REaCH system dashboard they need to easily understand how to navigate from one page to another. For example, on the dashboard side bar we have placed different buttons which links to each respective page. Also, the names on the buttons are easily understandable by the user.
- **Common design elements throughout the application-** We have placed all the tables, buttons, icons, logo consistently in the application. So that users has a good feel for the consistency and knows what to expect.
- **Some elements take precedence over others-** Another important design feature is when it comes to visuals and the human eye, A few elements proliferate over others (bigger sizes, bright colors, etc.), depending on how "noticeable" they are. For example, we have used the orange color to indicate that the first responder is in danger and red color for indicating which health indicator is causing or putting the first responder in danger.
- **Consistent design** - The user interface should consist of a minimum number of actions when user performing tasks. For example, if we want to delete the team, the user just clicks delete icon in the team page.
- **Consistent communication** - Every interaction with your user is communicated. For an application to be successful, it must speak to the user and keep them informed on what is happening. And, as with everything else, the way the system communicates should be consistent. For this project we had routine communication with real first responders and employed their feedback into the design.

Future Work

The future work for this prototype is developing the application which requires the following frameworks:

- Building the front end using Angular framework and styling with Angular Material
- Developing the backend using with Django REST API and Django framework
- Connecting the backend with PostgreSQL.
- Integrating front end and backend.
- Deploying and host the application on the HEROKU server.

This research is being conducted in collaboration with the Special Operations Team, Omaha Fire Department, who are responsible to contain hazmat incidents in the Omaha Metropolitan Area and UNL Nebraska Transportation Center.

Acknowledgement

Funding for this research is supported through a US Department of Transportation award number (25-1121-0005-1110)

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Contest 007
https://www.techtoprotectchallenge.org/contest/contest-007/

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Document Scope

This document captures all the design architectures used to build Reach system. The purpose of the document is to help understand Visual representation of the system.

Revision History

Rev. #	Date	Author	Description of Changes
0.1	04/06/2020	Anusha Manda	Added Sequence diagrams, Use case diagrams
0.2	04/13/2020	Anusha Manda	Added data dictionary and component diagrams
0.3	04/18/2020	Anusha Manda	Added Frameworks and patterns
0.4	04/192020	Anusha Manda	Added Deployment details
0.5	04/20/2020	Anusha Manda	Added security considerations and component diagrams for device page and person page
0.6	04/21/2020	Anusha Manda	Added Component diagrams of team's page device assignment and sequence diagrams of threshold page
0.7	04/21/2020	Anusha Manda	Added infrastructure diagram and device diagram

Approver Review

Rev. #	Date	Component	Approved by
0.1	03/10/2020	Sequence diagram for Login	Dr. Ann Fruhling, John Rodgers
0.2	03/13/2020	Device diagram	Dr. Ann Fruhling, John Rodgers
0.3	03/26/2020	Sequence diagram for Threshold page	Dr. Ann Fruhling, John Rodgers
0.4	03/31/2020	Sequence diagram for Device page and person page.	Dr. Ann Fruhling, John Rodgers
0.5	03/31/2020	UML Use case diagram	Dr. Ann Fruhling, John Rodgers
0.6	04/08/2020	Component diagram for device page, validation	Dr. Ann Fruhling, John Rodgers
0.7	04/14/2020	Component diagram for Threshold's page and person page	Dr. Ann Fruhling, John Rodgers
0.8	04/22/2020	Component diagram for Team's page and	Dr. Ann Fruhling, John Rodgers

		Device assignment page	

3 Reach system architecture

Security Considerations

Authentication Must be able to be accomplished without network access due to connectivity issues

- Usernames and Passwords
- Done using Django Authentication
- Session tokens handled with JWT Tokens

Future Considerations

- Authentication for the local network
- Devices may connect directly to the system

Authorization

- Administrators

Can manipulate the system including some data such as user accounts and teams.

- Base Level Users

Users can view some data

Sensitive Data Handling

- Data being handled may be considered PHI and may be considered sensitive
- Encryption in-transit with Unsigned Certificates
- SSL V3/TLS 1.3
- Future Considerations
- Encrypt data at rest? Ie. Encrypting database data

Input Validation/Output Encoding

- Client/Server-side Validation
    - Password validation mainly server-side

Future Considerations

- Data is being input from devices

File Upload

- Image files are going to be uploaded
- File upload security will be handled through trusted backend uploads

Logging

Logging information captured by the application includes the following elements

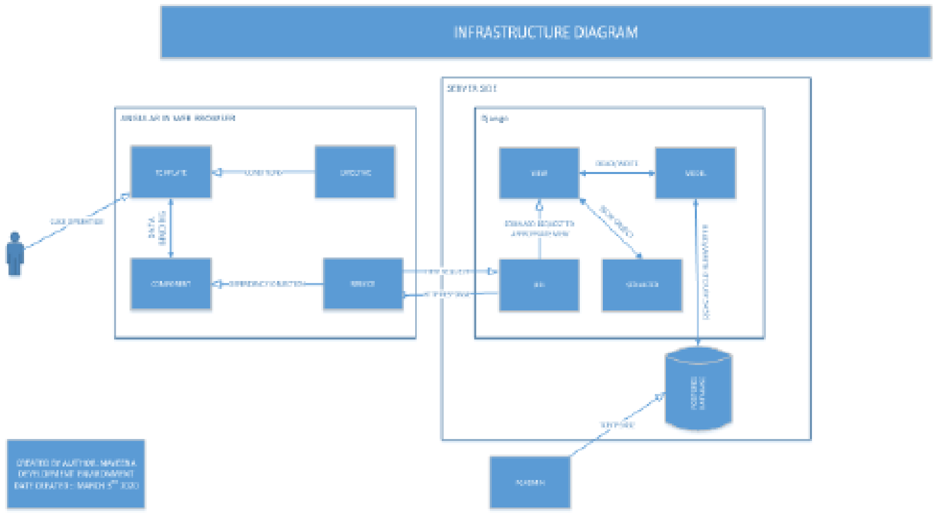
- IP Address
- User ID
- Date & Time
- Compliance/Security Related Action

Assumptions

- System Account Activity
    a. Users Creation
    b. Logins
    c. Data Manipulation
    d. Logging Using Django Built In Logging

Infrastructure Diagram

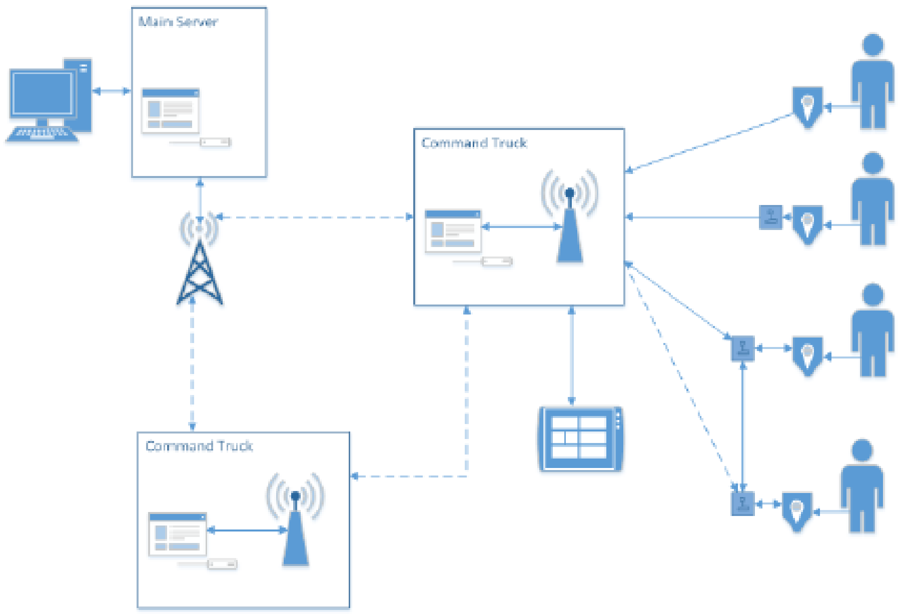
A technology **infrastructure diagram** provides a high-level graphical view of the physical architecture required to support the application architecture.



This diagram template uses the Tool, Visio which can be found at https://www.microsoft.com/en-us/microsoft-365/visio/flowchart-software

DEVICE DIAGRAM

This diagram gives an overview of how the system could be setup in the future. The components of this diagram are webservers, Wireless Radios within a truck or fixed, computers connected to the internet, tablet devices, shortwave wireless radios, health monitoring devices, and people.



This diagram template uses the Tool, Visio which can be found at https://www.microsoft.com/en-us/microsoft-365/visio/flowchart-software

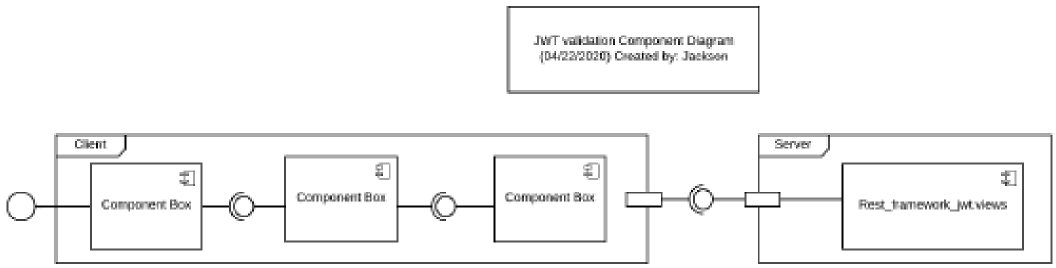
Starting from the computer, this computer is any computer or tablet or phone that is connected to the internet such that it can connect to the main server and retrieve the served web page. The Main Server is a fixed webserver that is always connected to the internet and acts as a source of data that other webservers can retrieve data from, or as a source of truth that can resolve conflicts. The Main Server can be connected to the Command Trucks through a WAN wireless system that may be transient, thus making it necessary that the Command Truck webservers need to be self-contained. The Command Trucks have wireless radios that can connect back to the Main Server as well as peer between each other.

On the right starting from the top are the different methods that Health Monitoring Devices can connect and send data back to the Command Truck:
First is a device that can connect directly to the Command Truck to send data.
Next is a device that connects to a shortwave radio and uses that network to send data to the Command Truck.
The next two are devices that connect to shortwave radios where one of the radios is unable to connect to the Command Truck and needs to mesh with another short-wave radio to send data back to the Command Truck.

COMPONENT MODELS

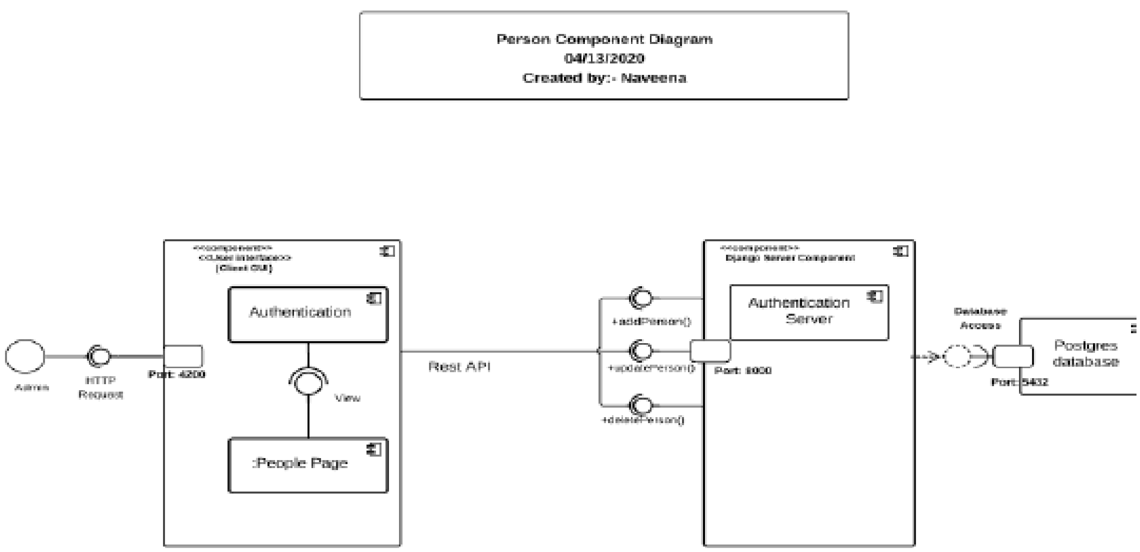
The following component models illustrate a static view, of the encapsulated software functions including services, batch processes, or modules illustrating their points of interaction. Textual descriptions follow the diagram.

COMPONENT DIAGRAM FOR VALIDATION



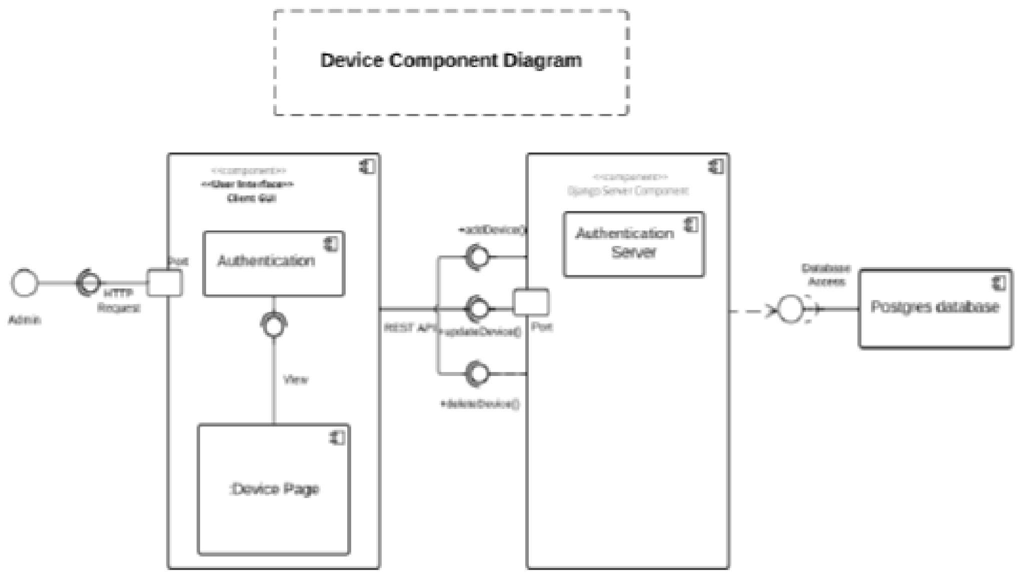
This Component diagram template is done by tool LUCID CHART, available at https://www.lucidchart.com/users/login:

COMPONENT DIAGRAM FOR PERSON PAGE



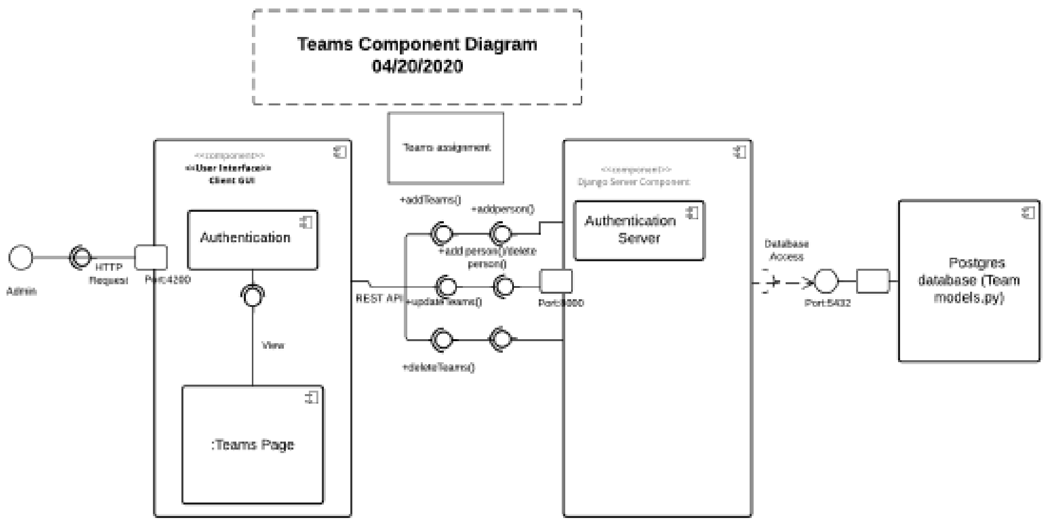
This Component diagram template is done by tool LUCID CHART, available at https://www.lucidchart.com/users/login:

COMPONENT DIAGRAM FOR DEVICE PAGE



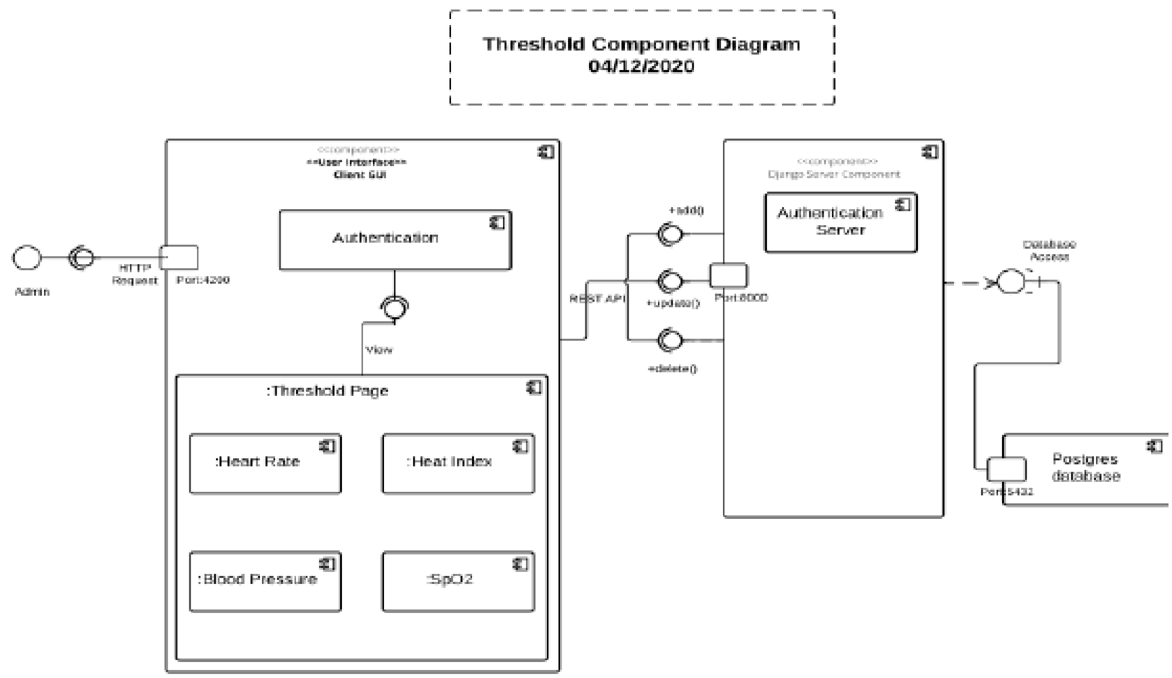
This Component diagram template is done by tool LUCID CHART, available at https://www.lucidchart.com/users/login*:*

Component diagram for Teams page



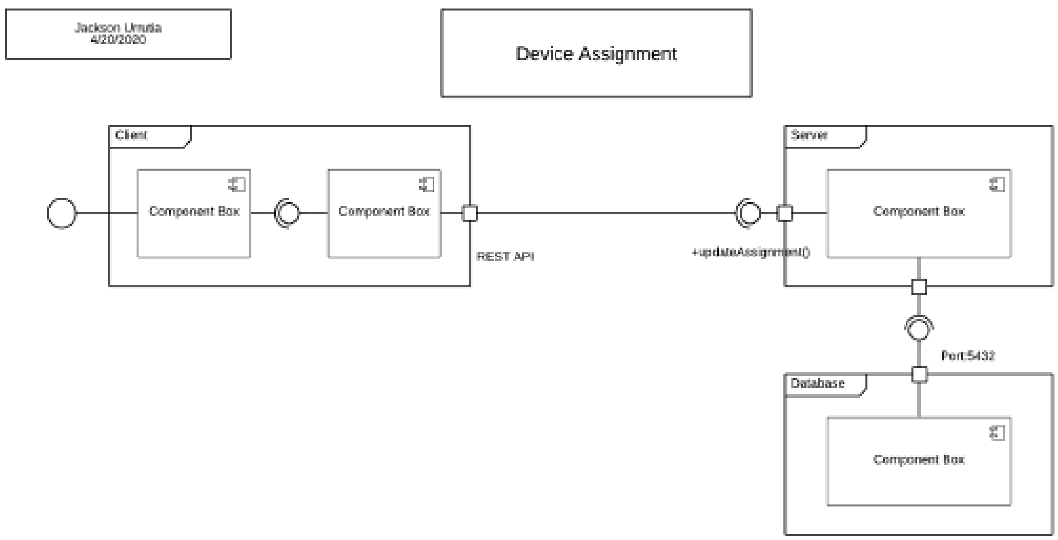
This Component diagram template is done by tool LUCID CHART, available at https://www.lucidchart.com/users/login:

Component diagram for Threshold page



This Component diagram template is done by tool LUCID CHART, available at https://www.lucidchart.com/users/login:

Component diagram for device assignment page



This diagram template uses the Tool, VISIO which can be found at https://www.microsoft.com/en-us/microsoft-365/blog/2017/03/01/visio-online-anywhere-anytime-access-to-your-diagrams/

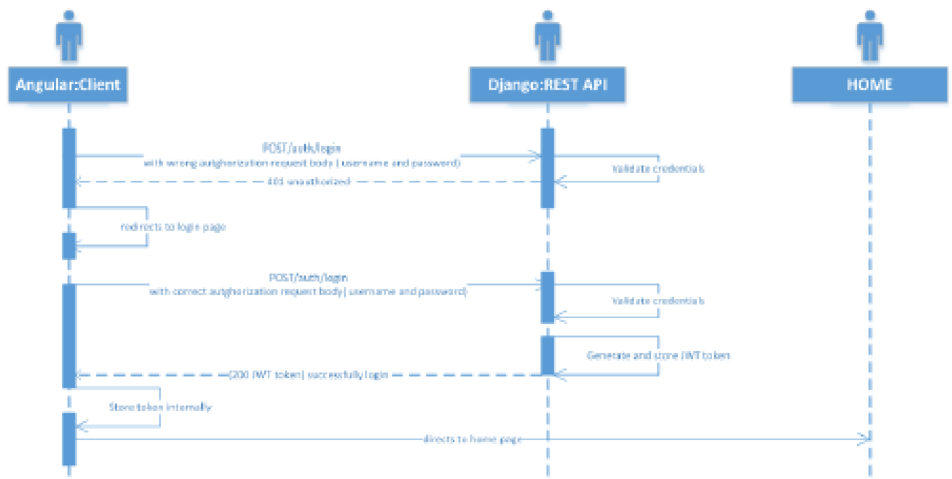
Sequence Diagrams

The following are UML Sequence Diagrams are interaction diagrams that detail how operations are carried out. They capture the interaction between objects in the context of a collaboration. Sequence Diagrams are time focus and they show the order of the interaction visually by using the vertical axis of the diagram to represent time what messages are sent and when

Sequence Diagram

Sequence diagrams are created for each functionality in the reach system in order to get better understanding on the flow between the objects. Diagrams bellow illustrates the sequence diagrams for login, device page, Peoples page, Threshold page

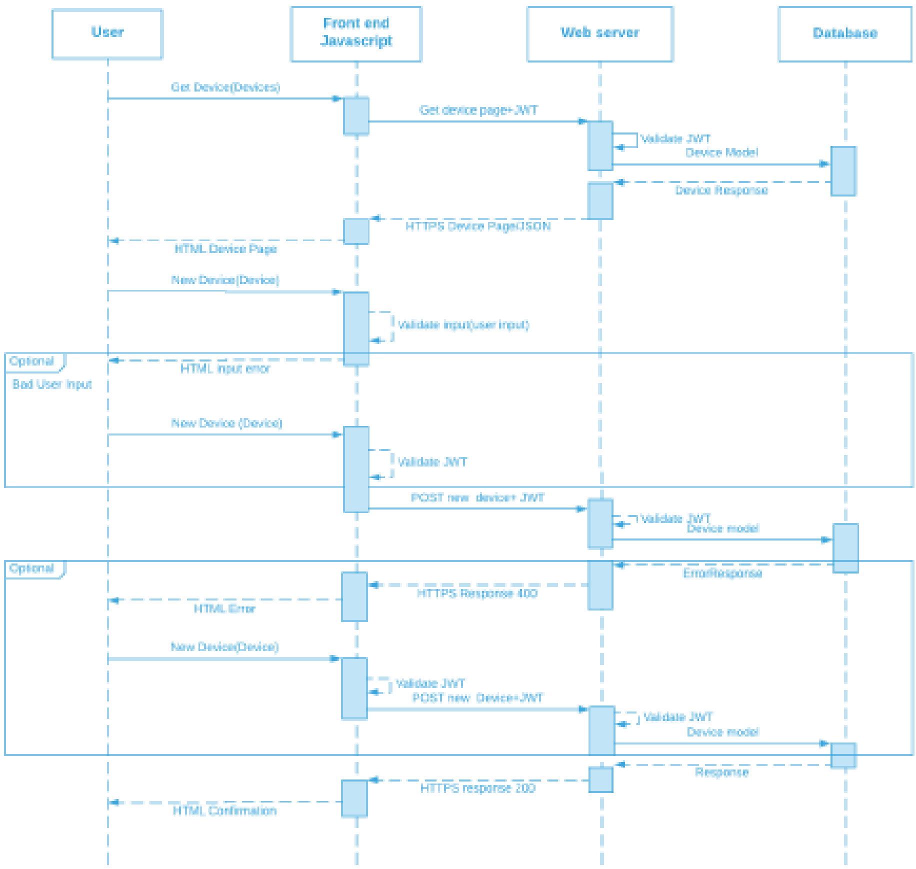
Sequence Diagram for login



This diagram template uses the Tool, VISIO which can be found at https://www.microsoft.com/en-us/microsoft-365/blog/2017/03/01/visio-online-anywhere-anytime-access-to-your-diagrams/

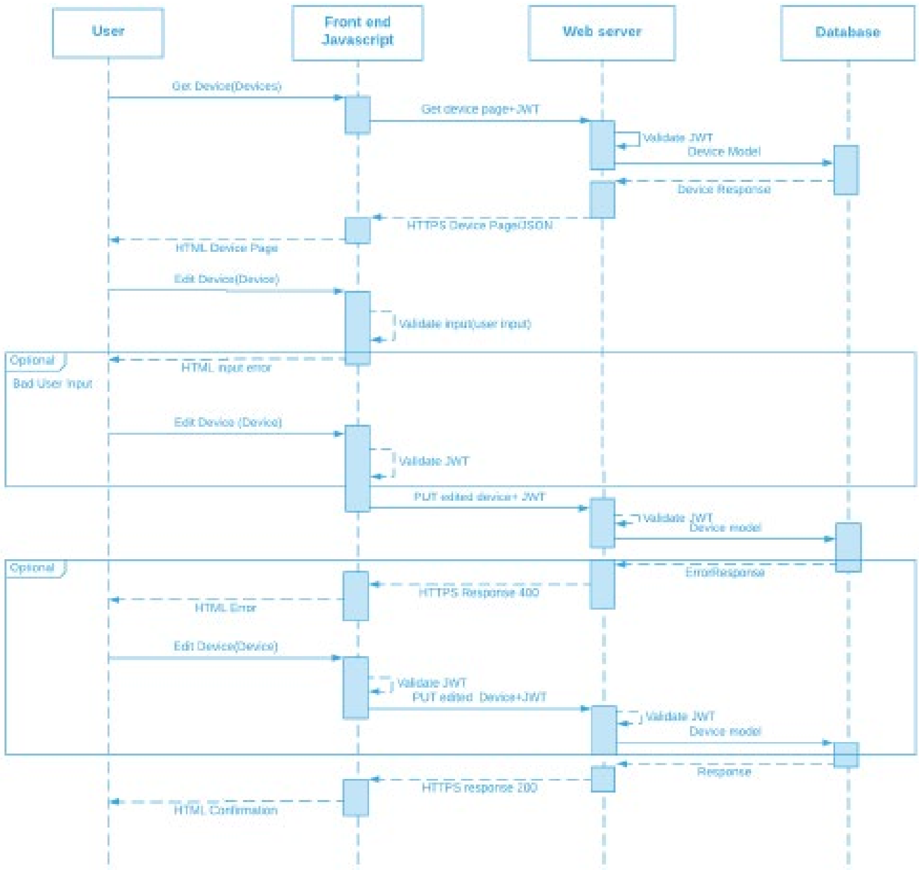
Sequence Diagram for device page

Add device



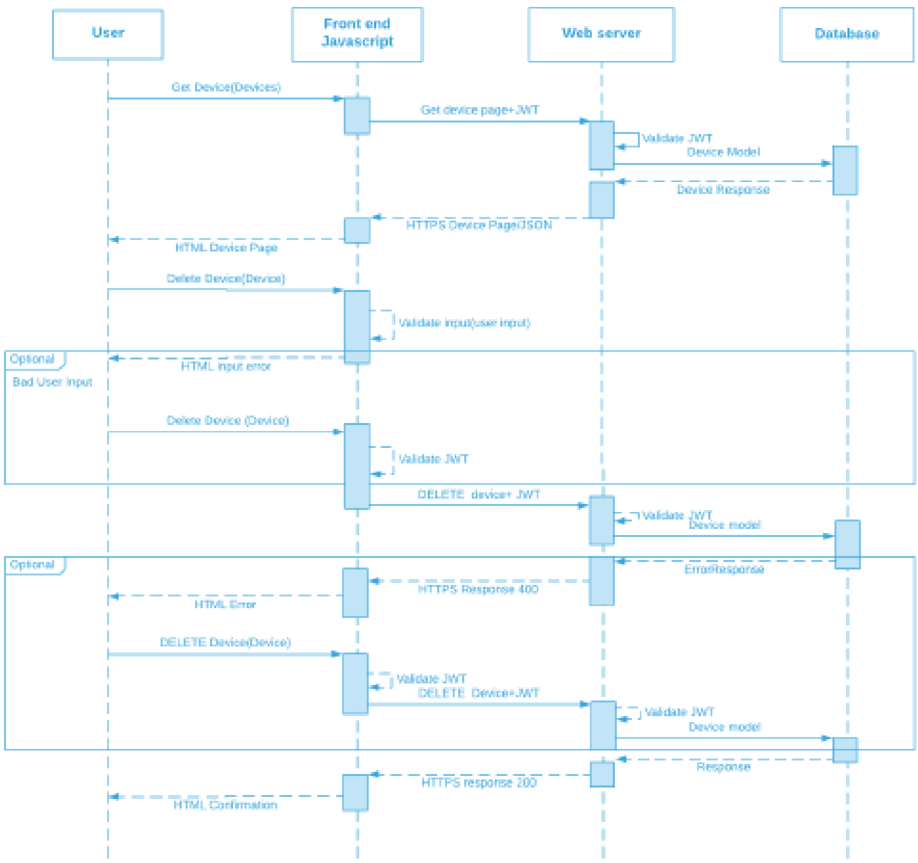
This diagram template uses the Tool, LUCID chart which can be found at https://www.lucidchart.com/users/login

Edit Device



This diagram template uses the Tool, LUCID chart which can be found at https://www.lucidchart.com/users/login

Delete device

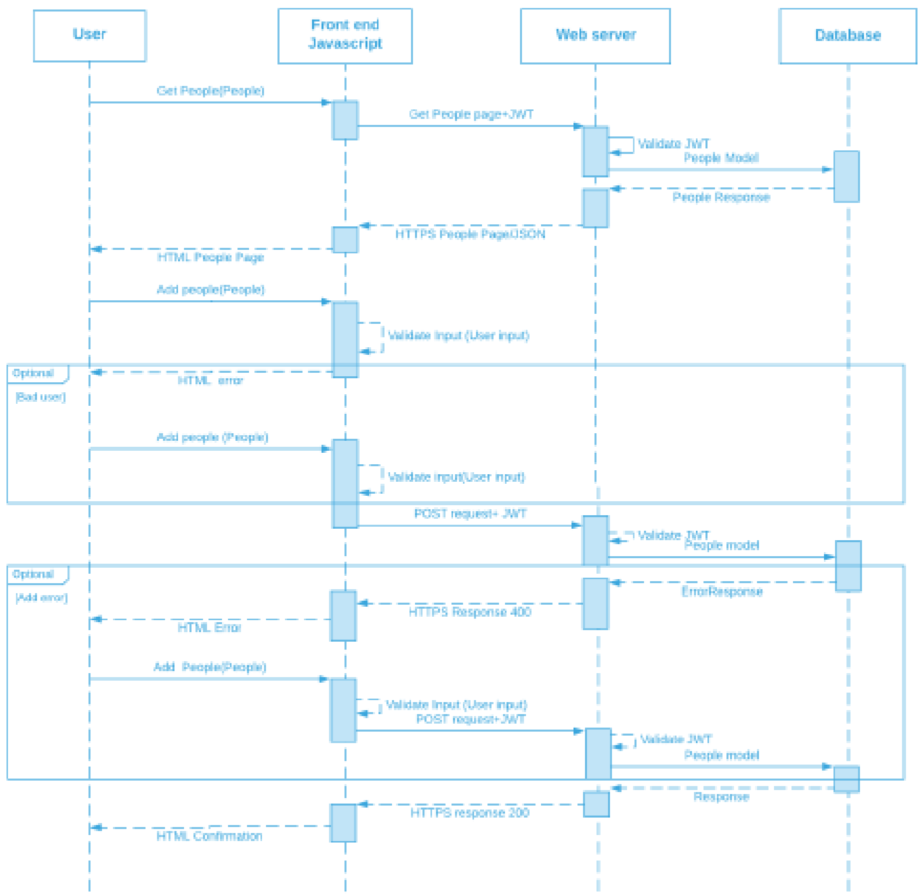


]

This diagram template uses the Tool, LUCID chart which can be found at https://www.lucidchart.com/users/login

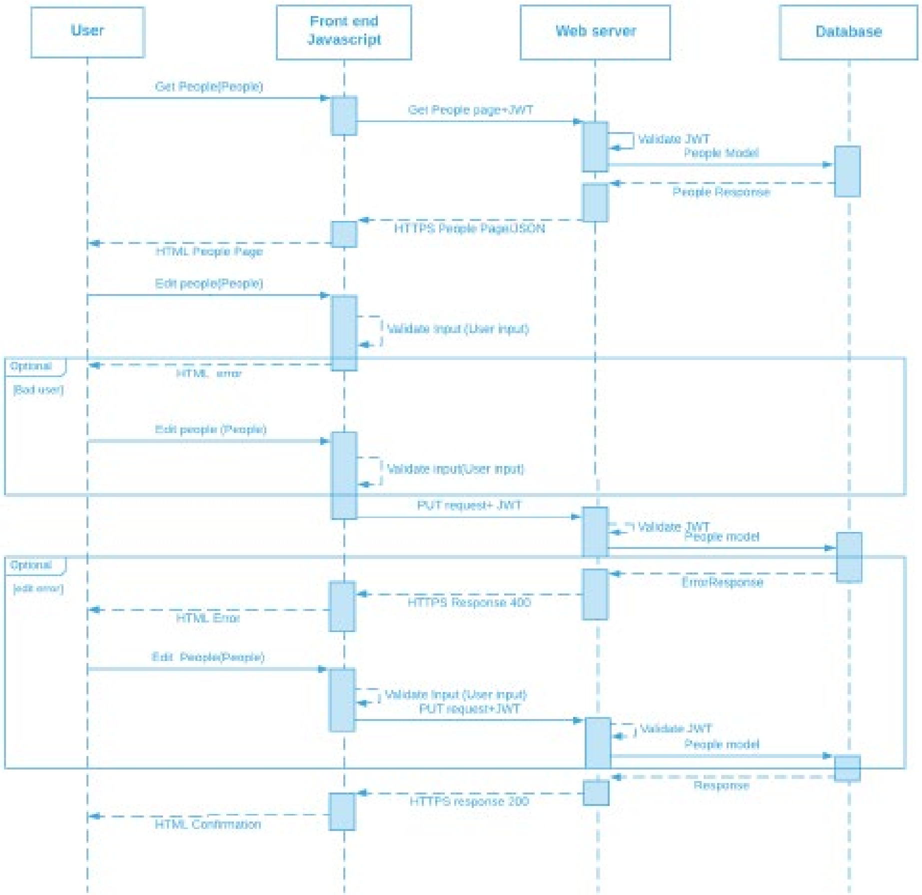
Sequence Diagram for person page

Add people



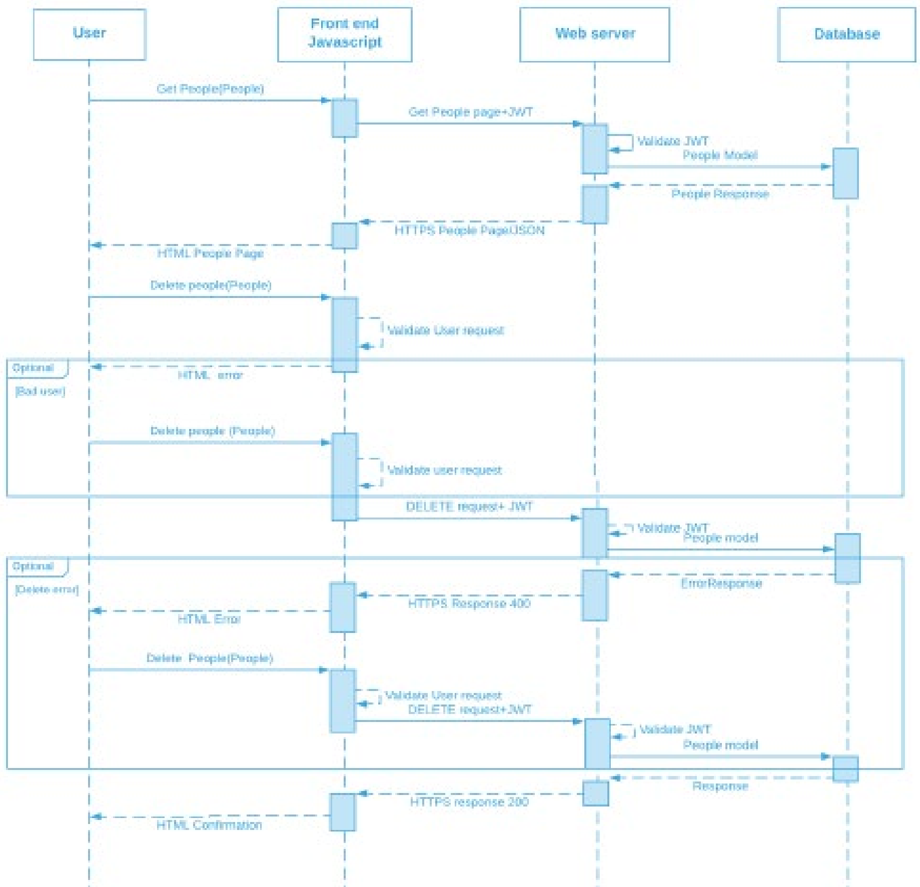
This diagram template uses the Tool, LUCID chart which can be found at https://www.lucidchart.com/users/login

Edit people



This diagram template uses the Tool, LUCID chart which can be found at https://www.lucidchart.com/users/login

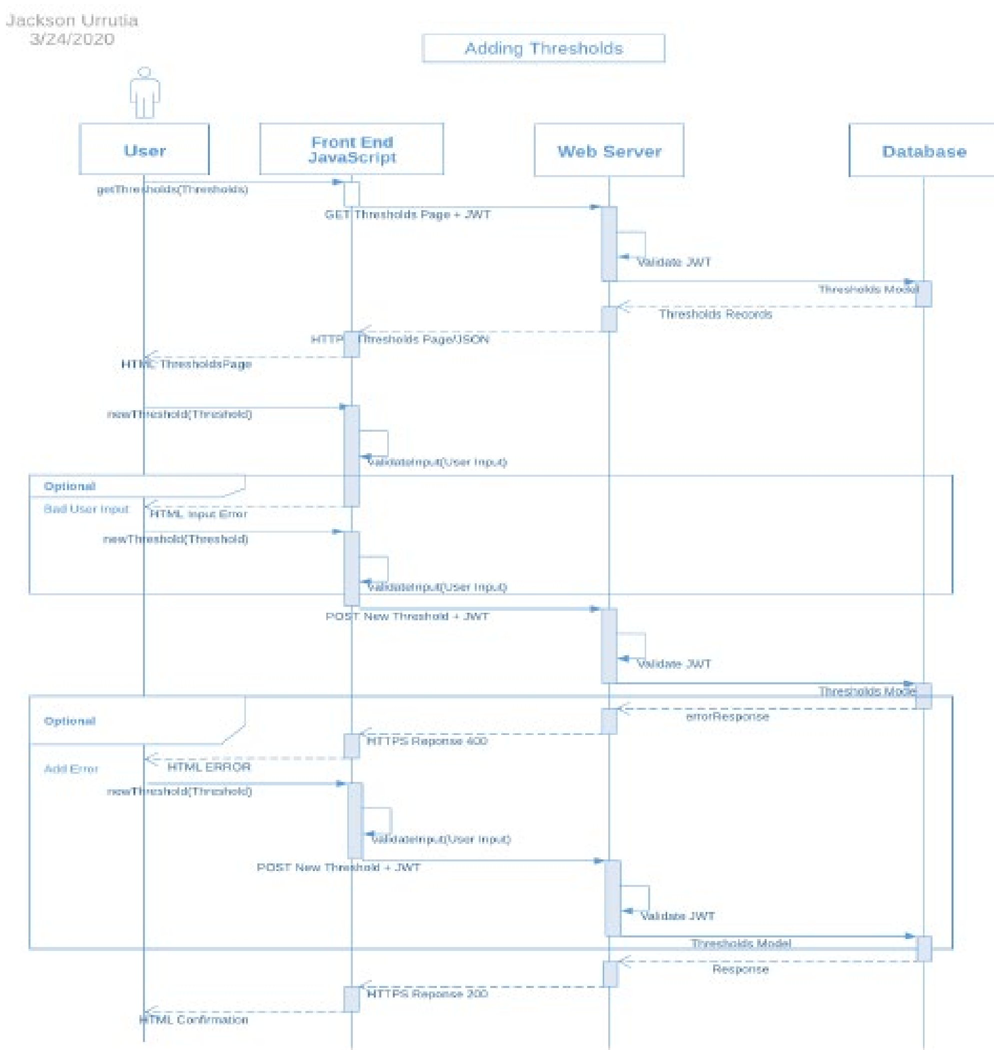
Delete people



This diagram template uses the Tool, LUCID chart which can be found at https://www.lucidchart.com/users/login

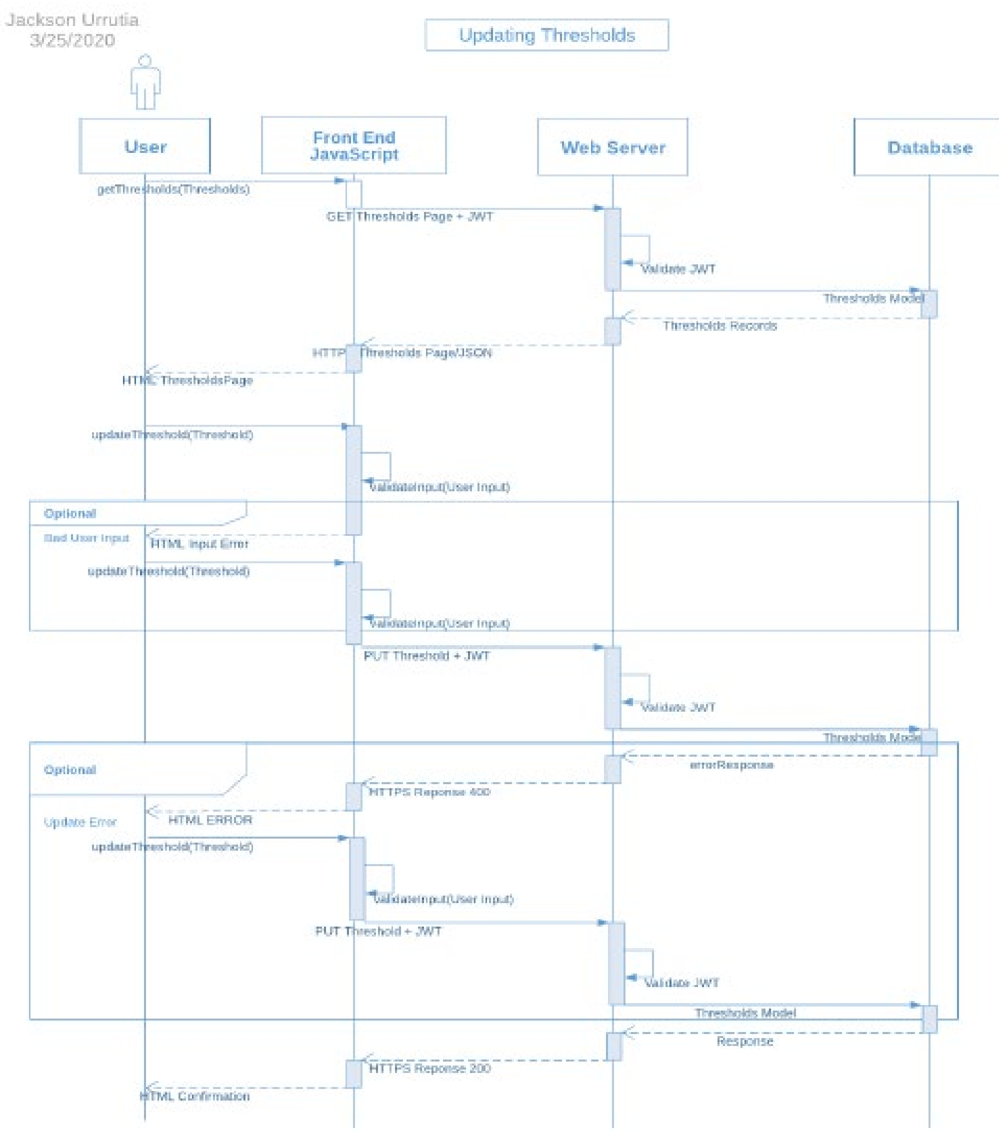
Sequence Diagram for threshold page

Add Threshold



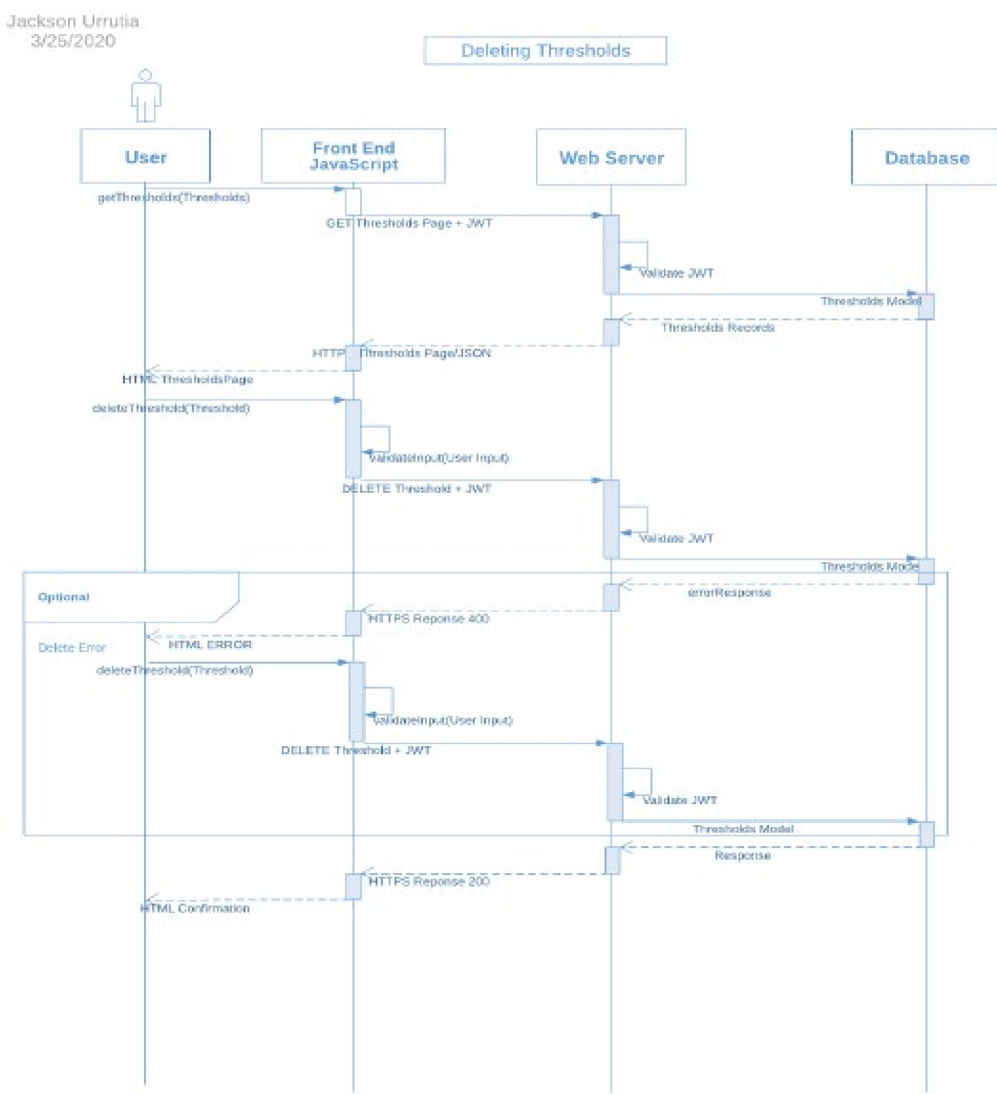
This diagram template uses the Tool, Visio which can be found at https://www.microsoft.com/en-us/microsoft-365/visio/flowchart-software

Update Threshold



This diagram template uses the Tool, Visio which can be found at https://www.microsoft.com/en-us/microsoft-365/visio/flowchart-software

Delete Threshold



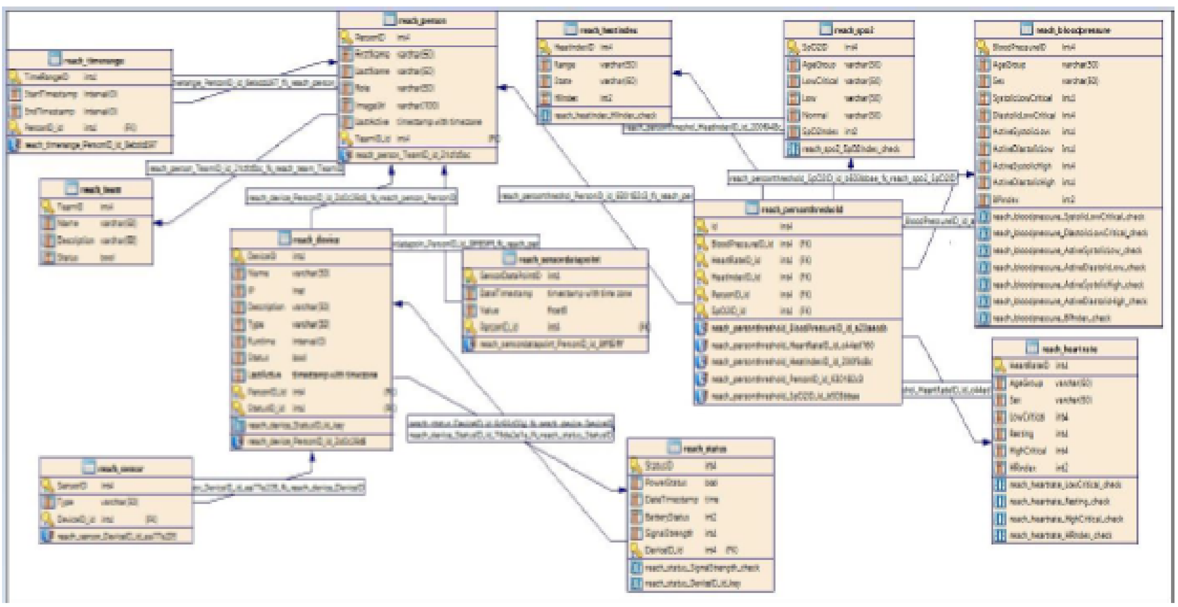
This diagram template uses the Tool, Visio which can be found at https://www.microsoft.com/en-us/microsoft-365/visio/flowchart-software

Entity Relationship Diagram

This entity relationship diagram (ERD) illustrates the database entities that make up the solution and their relationships to each other. Detailed descriptions of the required tables and their respective columns may be found after the diagram.

Entity Relationship Diagram

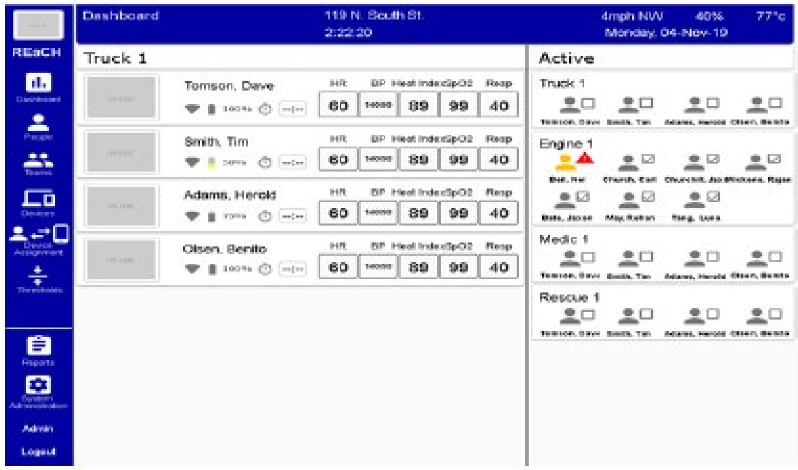
ER diagram explains the tables which are created in the database and how they are communicating with each other. In reach system, there is table created for each functionality i.e., device, people, threshold, sensor, team.



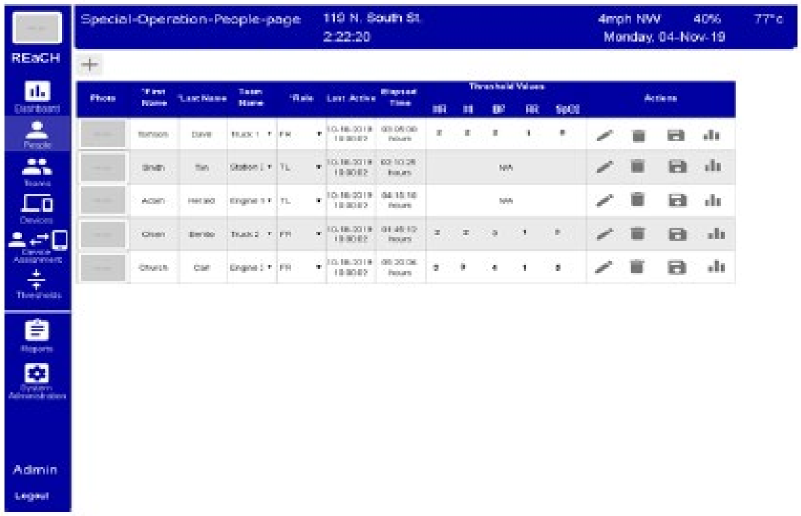
This diagram template uses the Tool, LUCID chart which can be found at https://www.lucidchart.com/users/login

Screenshots of Prototype

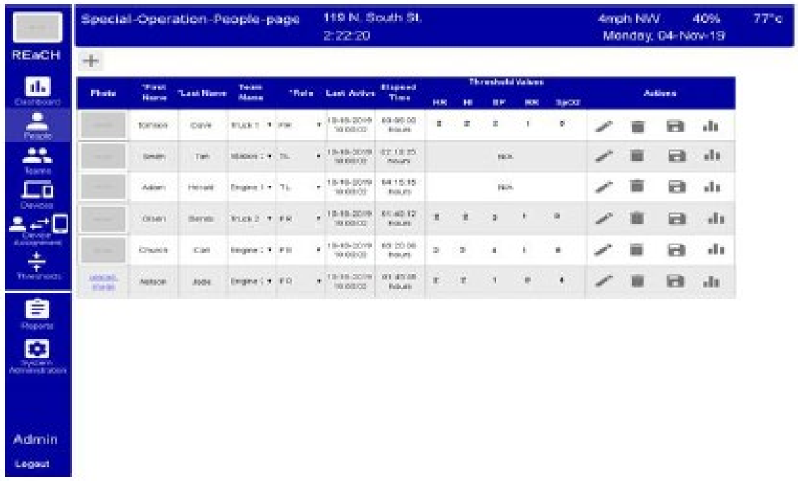
Dashboard Page



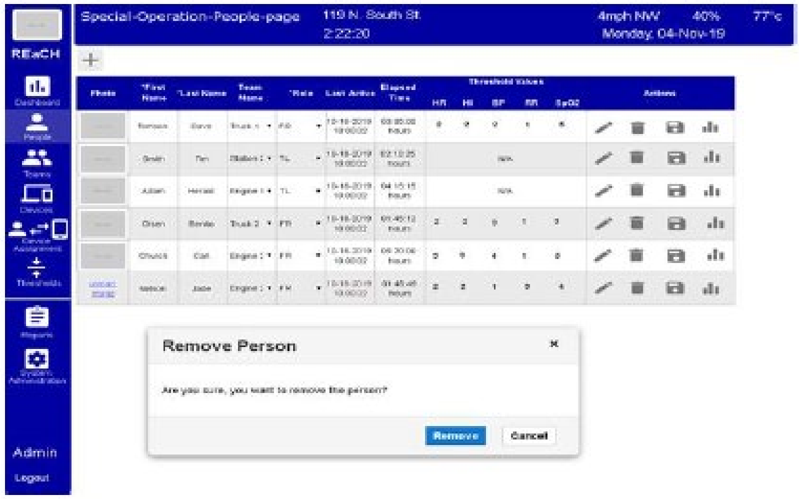
People's Page


Special-Operation-People-page
119 N. South St.
2:22:20
4mph NW
40%
77°c
Monday, 04-Nov-19
REaCH
Admin
Logout


Special-Operation-People-page
119 N. South St.
2:22:20
4mph NW
40%
77°c
Monday, 04-Nov-19
REaCH
Admin
Logout

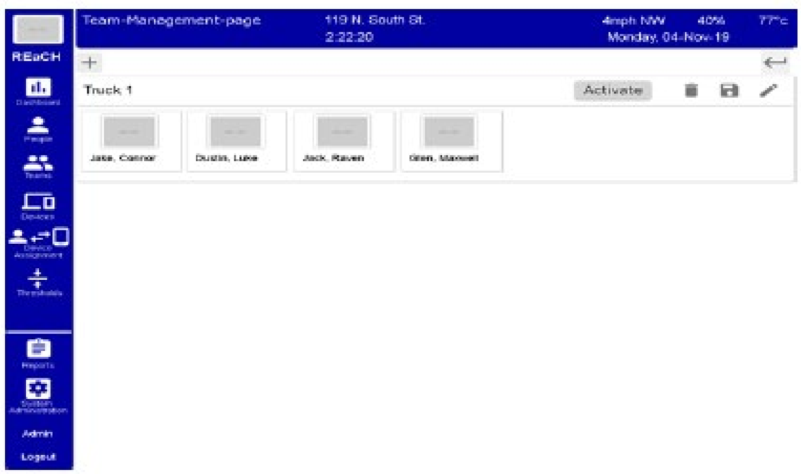


27 Reach system architecture

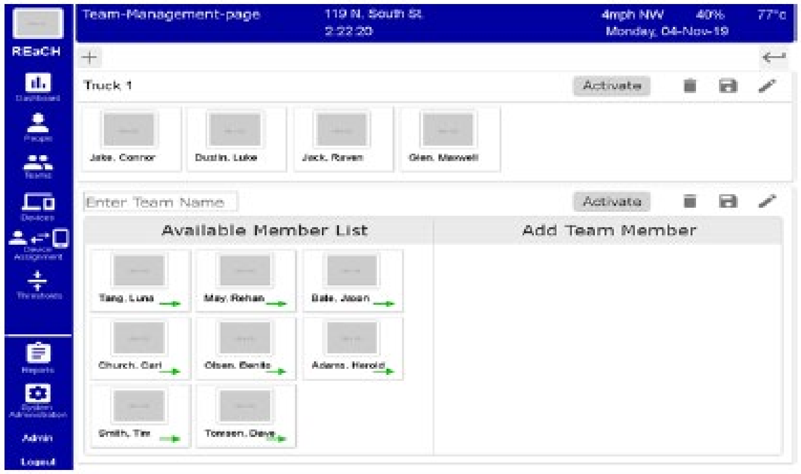


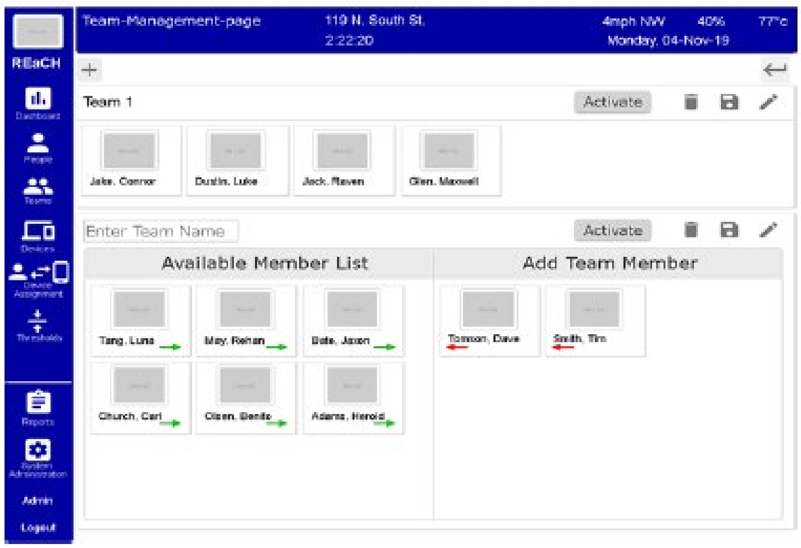
Special-Operation-People-page
119 N. South St.
2:22:20
4mph NW
40%
77°c
Monday, 04-Nov-19
REaCH
Remove Person
Are you sure, you want to remove the person?
Remove
Cancel
Admin
Logout

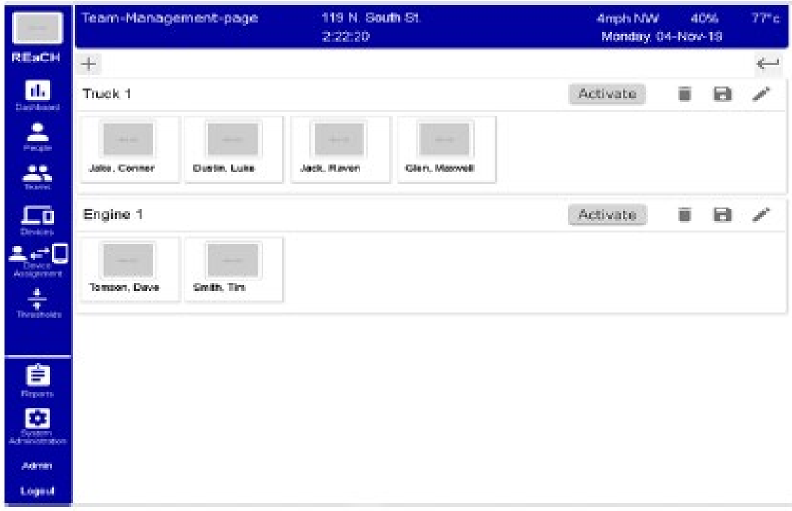
TEAM'S PAGE



Team-Management-page
119 N. South St.
2:22:20
4mph NW
40%
77°c
Monday, 04-Nov-19
REaCH
Truck 1
Activate
Jake, Connor
Dustin, Luke
Jack, Raven
Glen, Maxwell
Admin
Logout

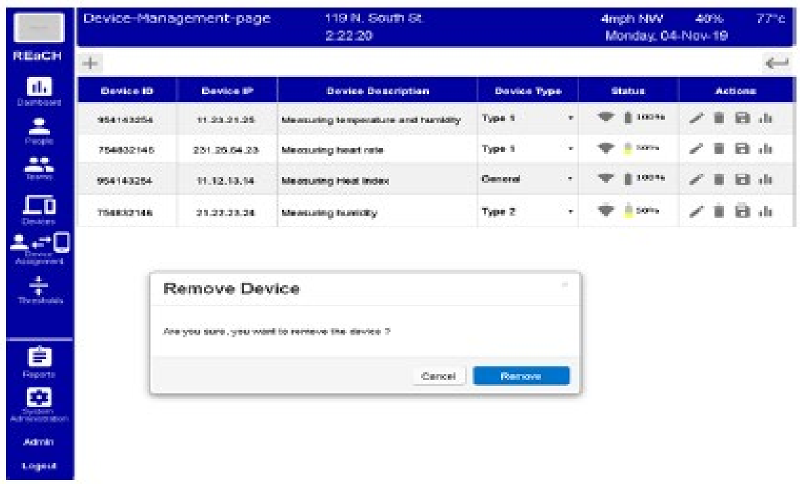

Team-Management-page
119 N. South St.
2:22:20
4mph NW
40%
77°c
Monday, 04-Nov-19
REaCH
Truck 1
Activate
Jake, Connor
Dustin, Luke
Jack, Raven
Glen, Maxwell
Enter Team Name
Activate
Available Member List
Add Team Member
Tang, Luna
May, Rehan
Bate, Jason
Church, Carl
Olsen, Benito
Adams, Herold
Smith, Tim
Tomsen, Dave
Admin
Logout


Team-Management-page
119 N. South St.
2:22:20
4mph NW
40%
77°c
Monday, 04-Nov-19
REaCH
Team 1
Activate
Jake, Connor
Dustin, Luke
Jack, Raven
Glen, Maxwell
Enter Team Name
Activate
Available Member List
Add Team Member
Tang, Luna
May, Rehan
Bate, Jason
Church, Carl
Olsen, Benito
Adams, Herold
Tomson, Dave
Smith, Tim
Admin
Logout


Team-Management-page
119 N. South St.
2:22:20
4mph NW
40%
77°c
Monday, 04-Nov-19
REaCH
Truck 1
Activate
Engine 1
Activate
Dashboard
People
Teams
Devices
Device Assignment
Thresholds
Reports
System Administration
Admin
Logout

Device Page


Device-Management-page
119 N. South St.
2:22:20
4mph NW
40%
77°c
Monday, 04-Nov-19
REaCH
Device ID
Device IP
Device Description
Device Type
Status
Actions
Measuring temperature and humidity
Type 1
Measuring heart rate
Type 1
Admin
Logout



Device -Assignment Page

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Threshold Page

Site-Administration Page


Site-Administration-page
119 N. South St.
77°c
22m20s
Monday, 04-Nov-19 17:53:27 UTC
REaCH
Health Status
Danger
Normal
1
30
User Accounts
Logged In Users
User Accounts
3
250
People
In Service
Out of Service
2
29
Teams
Active Teams
Inactive Teams
2
1
Devices
Assigned
Unassigned
Status Alert
Status Normal
31
2
1
30
System Performance
Connections
Network
Disk Usage
36
50mbps
350gb/2tb
System Alerts
Communication Failure
Unexpected Shutdown
System notifications
Connection Ended
Disk Usage at 10%
New Connection
System Booted
Notifications
Pending
Historical
Admin
Logout


Site Administration / Users
119 N. South St.
77°c
22m20s
Monday, 04-Nov-19 17:53:27 UTC
REaCH
Users
Admin, Admin
Username: Admin
Name: Admin,Admin
Email: Admin@email.com
Password: ****************
Last Login: Monday, 04-Nov-19 16:53:27 UTC
Admin
Logout

Information Flows

These information flow diagrams illustrate the flow of information across the system.

[An information flow is a less formal diagram that may take on whatever form is appropriate to effectively and clearly communicate the flow of information across a system. When a solution includes a significant data flow and/or ETL implementation, this section should be included to illustrate the high-level flow of information between major components listed above in the "Component Models" section. It should always include service endpoints, messaging functions, and file I/O.]

Frameworks and Patterns

The following frameworks and patterns will be used by this project.

Angular8: Angular is a platform and framework for building single-page client applications using HTML and TypeScript. Angular is written in TypeScript. It implements core and optional functionality as a set of TypeScript libraries that you import into your apps.

To get start with angular and for more details on installation and creating working environment please visit https://angular.io/start

Python-Django Framework: Django is a high-level Python web framework that enables rapid development of secure and maintainable websites. Built by experienced developers, Django takes care of much of the hassle of web development, so you can focus on writing your app without needing to reinvent the wheel. It is free and open source, has a thriving and active community, great documentation, and many options for free and paid-for support. Currently we are using Django 3.0

For detail steps on installation visit https://docs.djangoproject.com/en/3.0/topics/install/

PostgreSQL: Postgres is a powerful, open source object-relational database system. PostgreSQL. features transactions with Atomicity, Consistency, Isolation, Durability (ACID) properties, automatically updatable views, materialized views, triggers, foreign keys, and stored procedures. It is designed to handle a range of workloads, from single machines to data warehouses or Web services with many concurrent users. It is the default database for macOS Server and is also available for Linux, FreeBSD, OpenBSD, and Windows. Currently we are using Postgres version 12.2 for both Mac and windows.

Installation and use of PostgreSQL can be done by referring to development environment documentation which can be found under https://unomaha.app.box.com/file/631407180911

Postgres can be downloaded from https://www.enterprisedb.com/downloads/postgres-postgresql-downloads

Process Models

This project requires the use of one or more non-standard software development processes as described here.

Versioning

Releases

Deployment Information

The project will generate deployable artifacts. The following provides details about those artifacts and any additional processes that they require.

Deployable Files

Heroku: Heroku is a container-based cloud Platform as a Service (PaaS). Developers use Heroku to deploy, manage, and scale modern apps. Our platform is elegant, flexible, and easy to use, offering developers the simplest path to getting their apps to market.

Files required while deploying to Heroku can be accessed through https://unomaha.app.box.com/folder/108100783476

To get started with Heroku please visit https://signup.heroku.com/t/platform?c=70130000001xDpdAAE&gclid=EAIaIQobChMIzp7Jhu366AIVkvvjBx3zXw1jEAAYASAAEgJ8YPD_BwE

To install Heroku toolbelt (Heroku CLI) please visit https://devcenter.heroku.com/articles/heroku-cli

Configuration

Static Content

Deployment Process

There are multiple process in which we can deploy code to Heroku. Always make sure to make a copy of the folder, which ensures you have a backup if something goes wrong while deploying.

Push your code to GitHub by creating a branch of your name in Reach repository, which is available at https://github.com/uno-public-health-informatics-lab/REACH

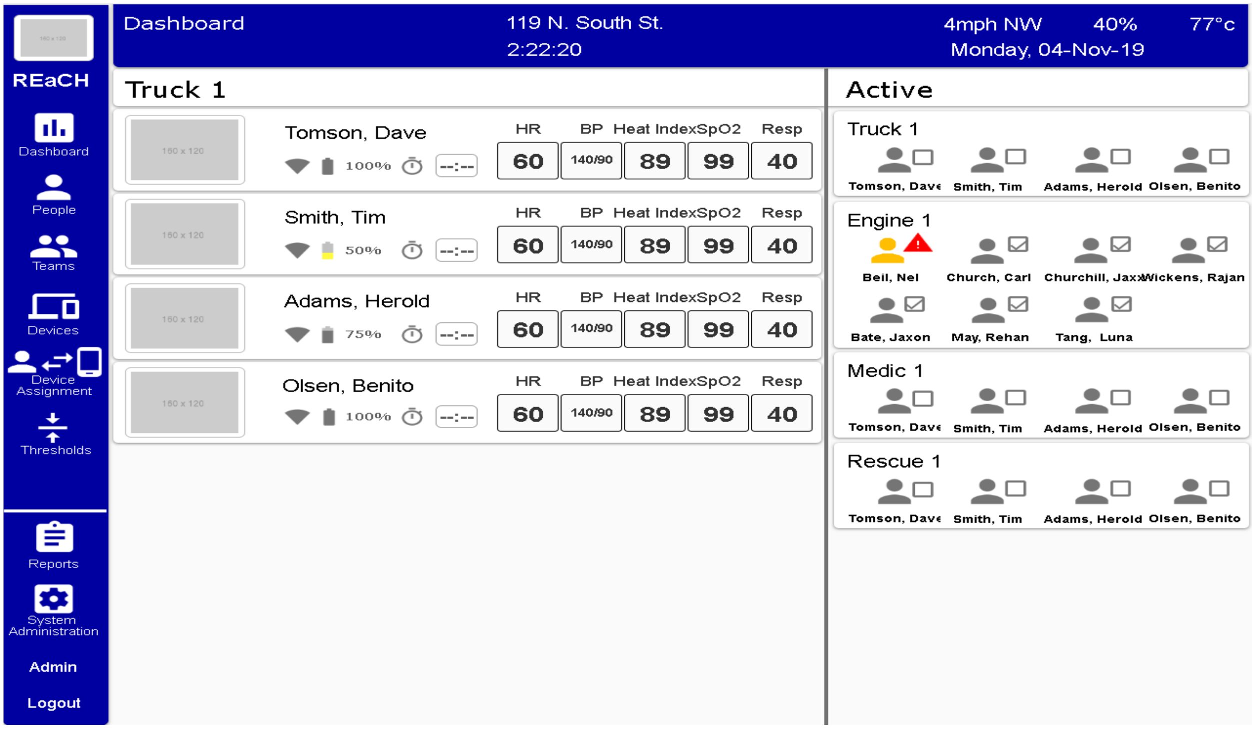
Information regarding deploying code through Github can be found in https://github.com/uno-public-health-informatics-lab/REACH

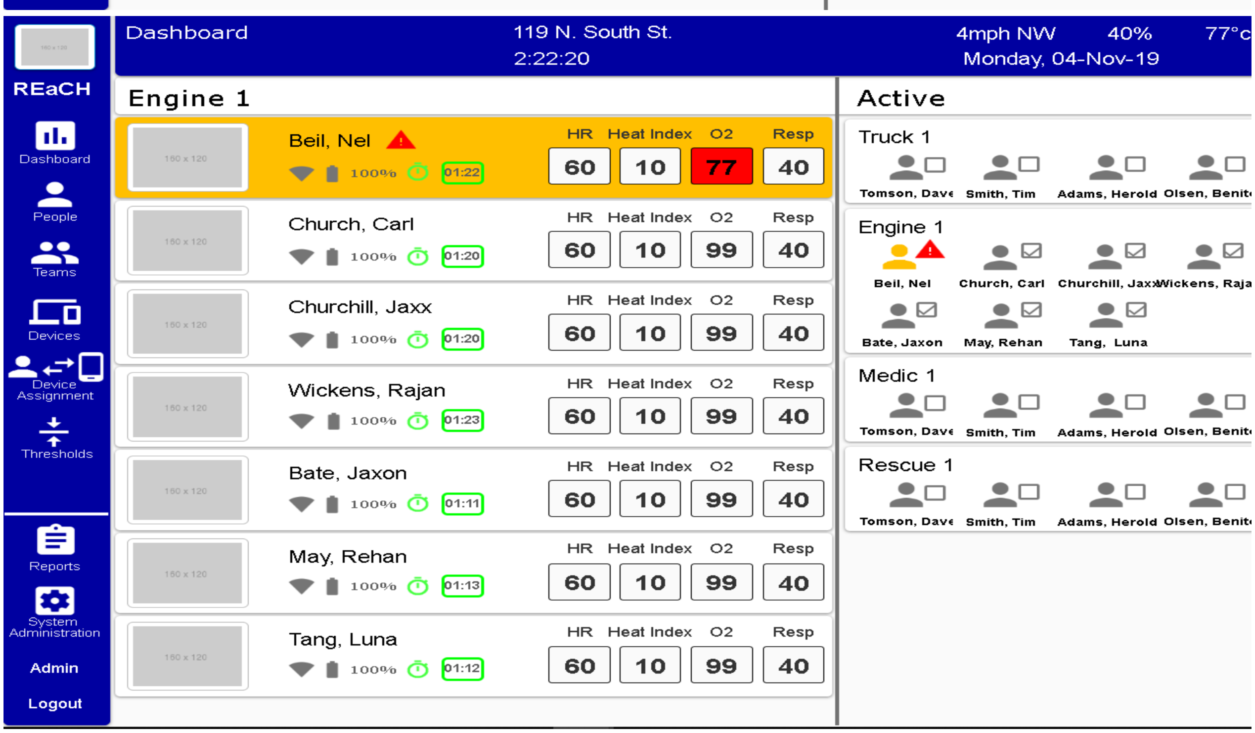
Reach application is deployed in Heroku and can be accessed through http://hazmat-reach-cat.herokuapp.com/

Appendix F REaCH System User Interfae Prototype Documentation

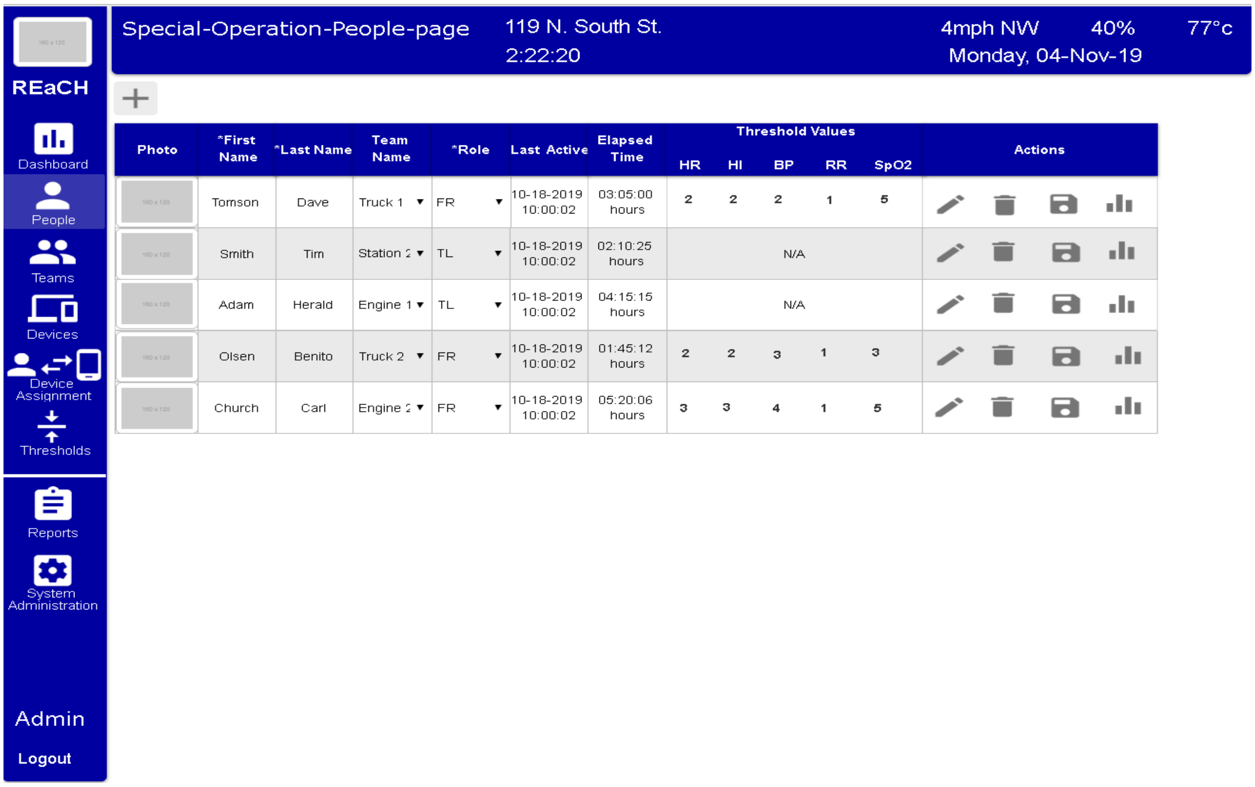
REaCH system

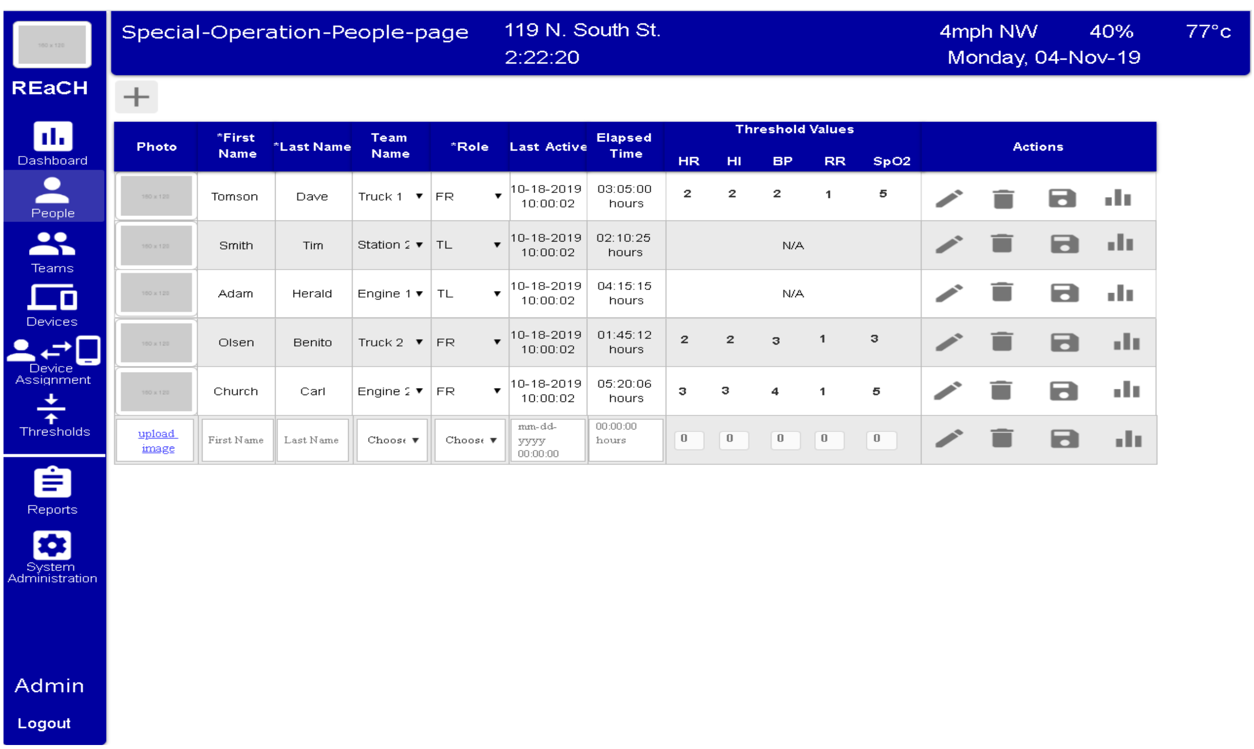
Dashboard Page

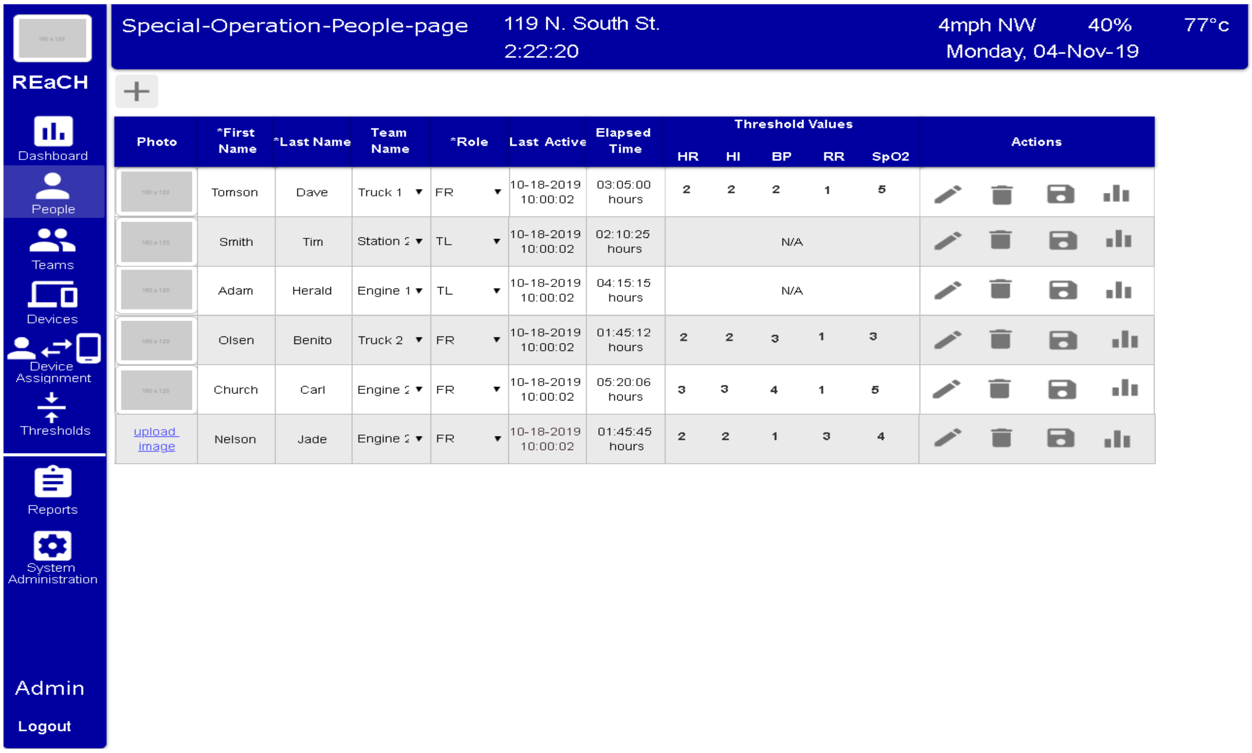


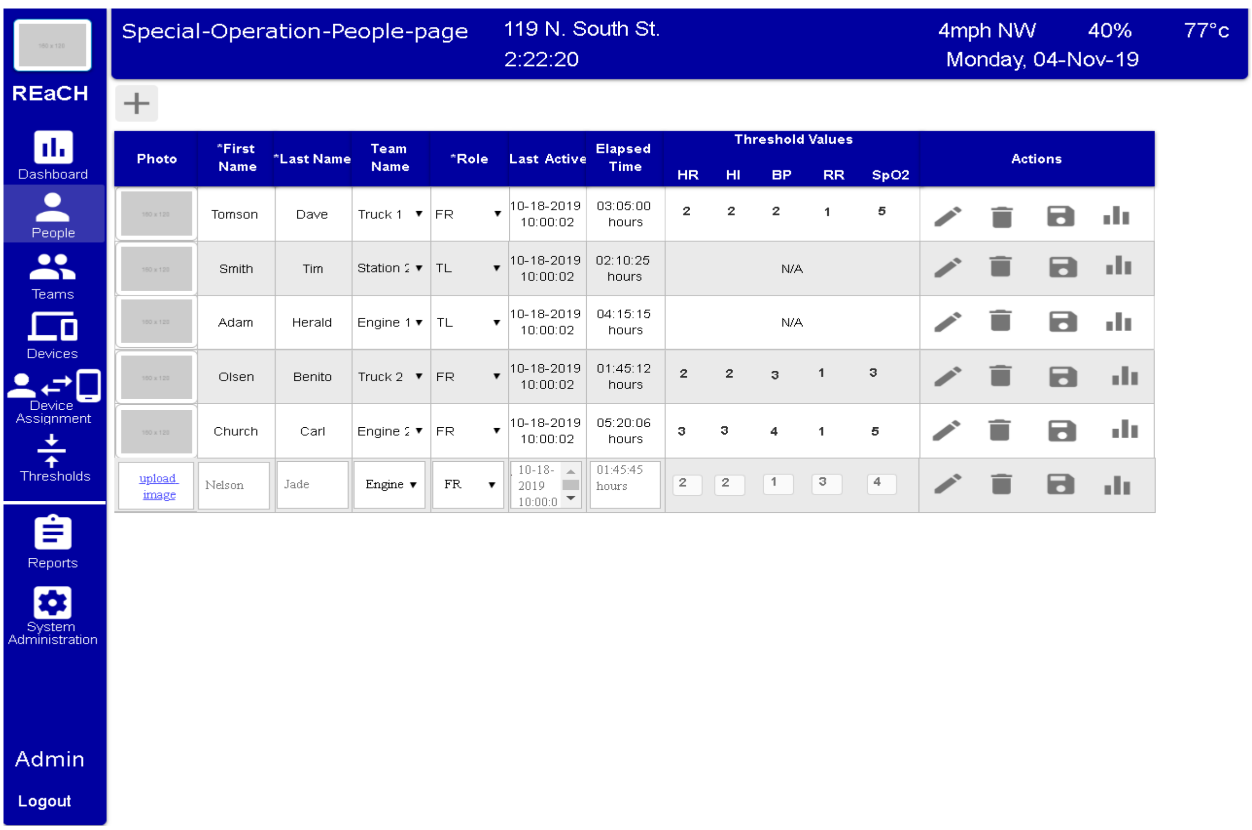


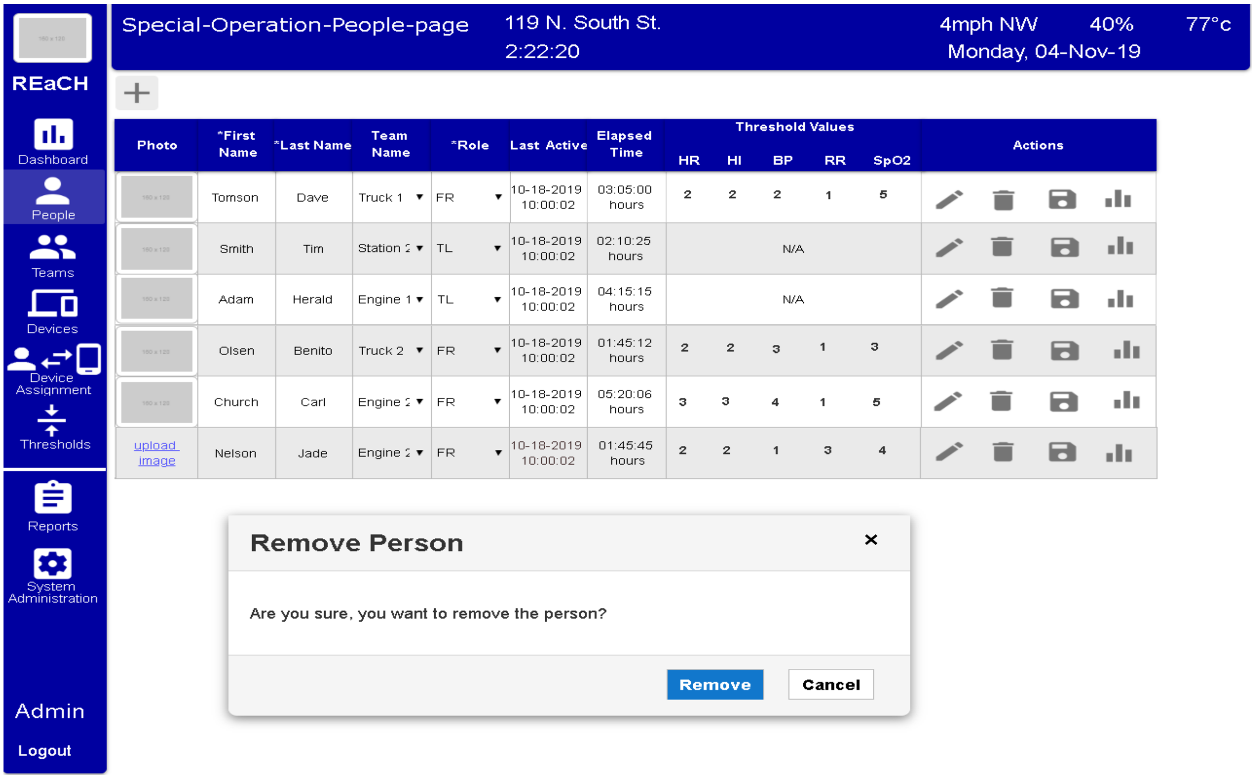
People’s Page



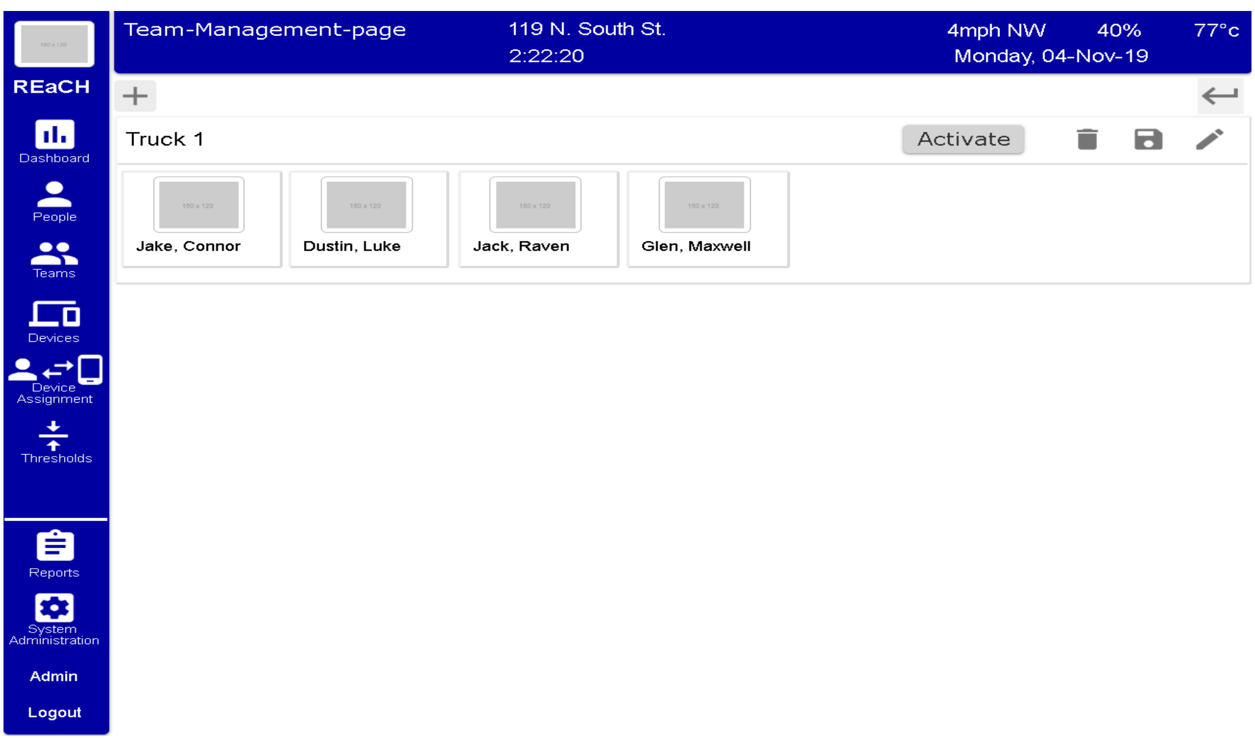


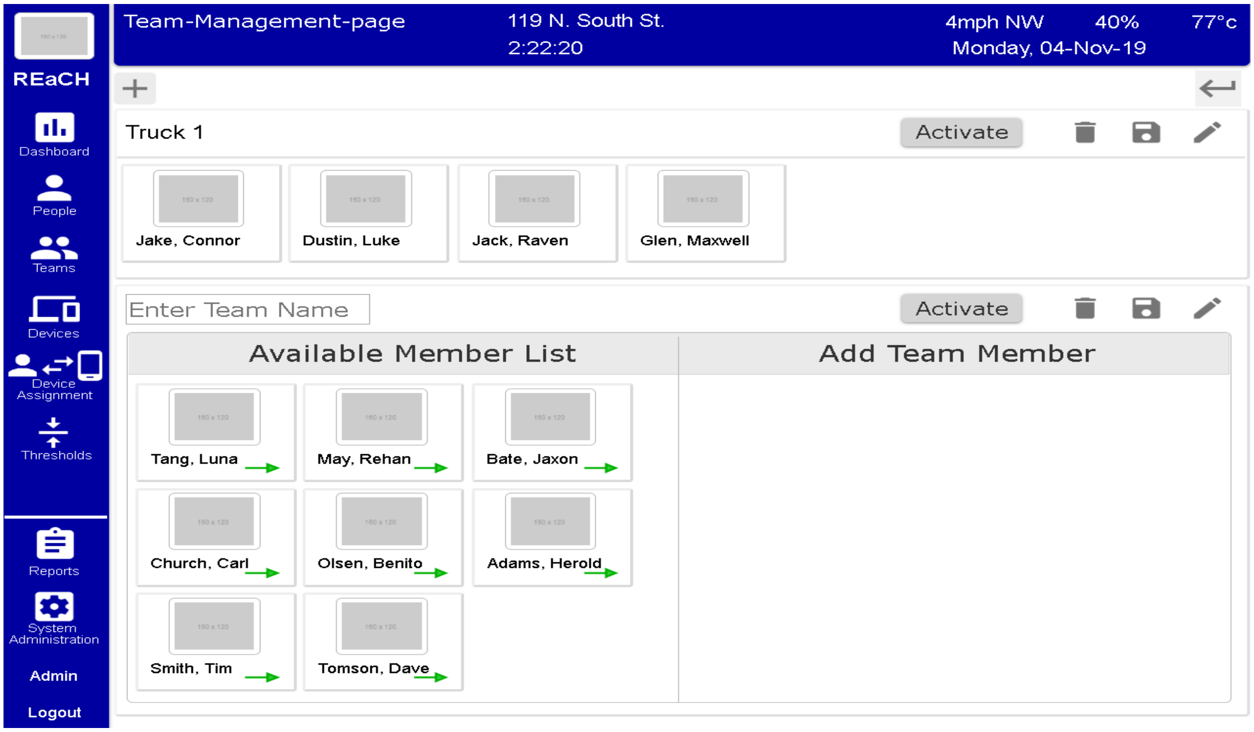

REaCH
Dashboard
People
Teams
Devices
Device Assignment
Thresholds
Reports
System Administration
Admin
Logout
Special-Operation-People-page
119 N. South St.
2:22:20
4mph NW
40%
77°c
Monday, 04-Nov-19
+
Photo
*First Name
*Last Name
Team Name
*Role
Last Active
Elapsed Time
Threshold Values
HR
HI
BP
RR
SpO2
Actions
Tomson
Dave
Truck 1
FR
10-18-2019 10:00:02
03:05:00 hours
2 2 2 1 5
Smith
Tim
Station 2
TL
10-18-2019 10:00:02
02:10:25 hours
N/A
Adam
Herald
Engine 1
TL
10-18-2019 10:00:02
04:15:15 hours
N/A
Olsen
Benito
Truck 2
FR
10-18-2019 10:00:02
01:45:12 hours
2 2 3 1 3
Church
Carl
Engine 2
FR
10-18-2019 10:00:02
05:20:06 hours
3 3 4 1 5
upload image
Nelson
Jade
Engine 2
FR
10-18-2019 10:00:02
01:45:45 hours
2 2 1 3 4

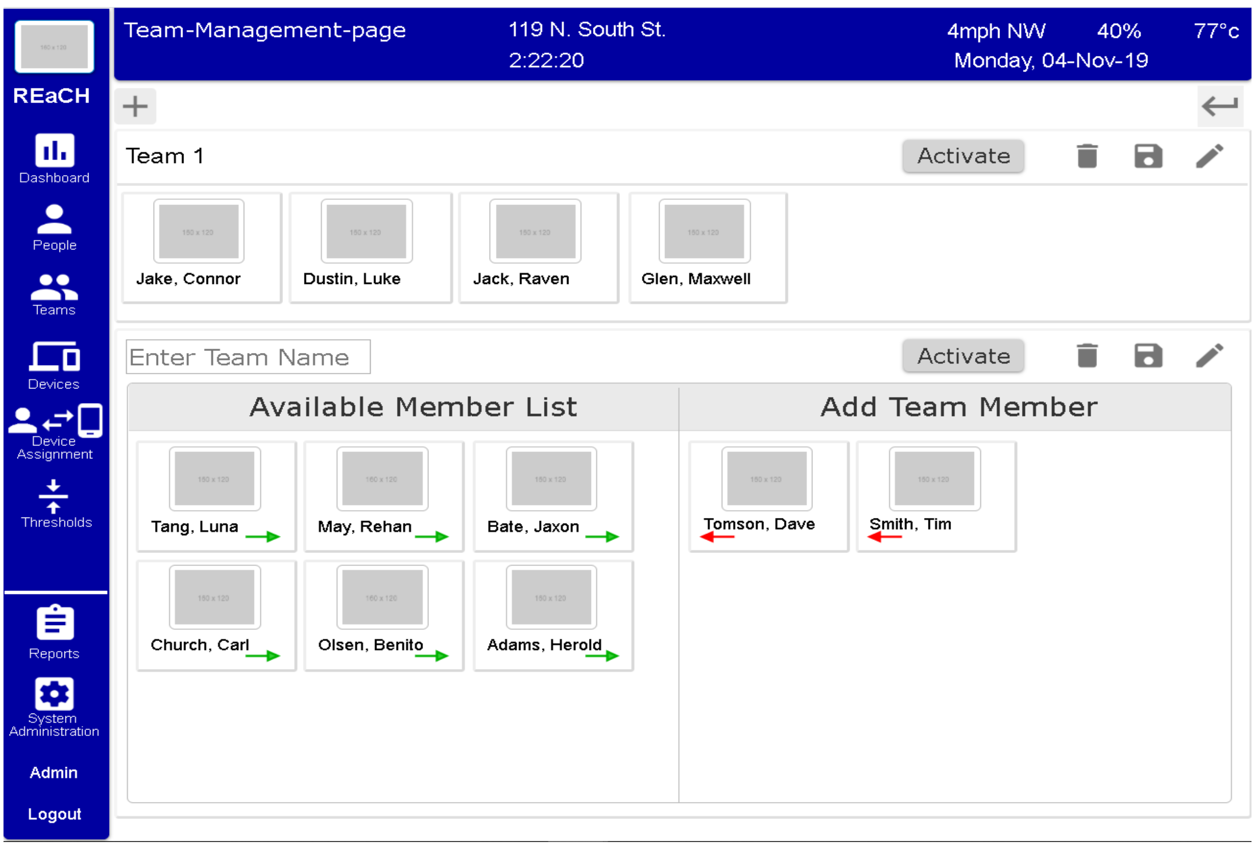

REaCH
Dashboard
People
Teams
Devices
Device Assignment
Thresholds
Reports
System Administration
Admin
Logout
Special-Operation-People-page
119 N. South St.
2:22:20
4mph NW
40%
77°c
Monday, 04-Nov-19
+
Photo
*First Name
*Last Name
Team Name
*Role
Last Active
Elapsed Time
Threshold Values
HR
HI
BP
RR
SpO2
Actions
Tomson
Dave
Truck 1
FR
10-18-2019 10:00:02
03:05:00 hours
2 2 2 1 5
Smith
Tim
Station 2
TL
10-18-2019 10:00:02
02:10:25 hours
N/A
Adam
Herald
Engine 1
TL
10-18-2019 10:00:02
04:15:15 hours
N/A
Olsen
Benito
Truck 2
FR
10-18-2019 10:00:02
01:45:12 hours
2 2 3 1 3
Church
Carl
Engine 2
FR
10-18-2019 10:00:02
05:20:06 hours
3 3 4 1 5
upload image
Nelson
Jade
Engine
FR
10-18-2019 10:00:0
01:45:45 hours
2 2 1 3 4

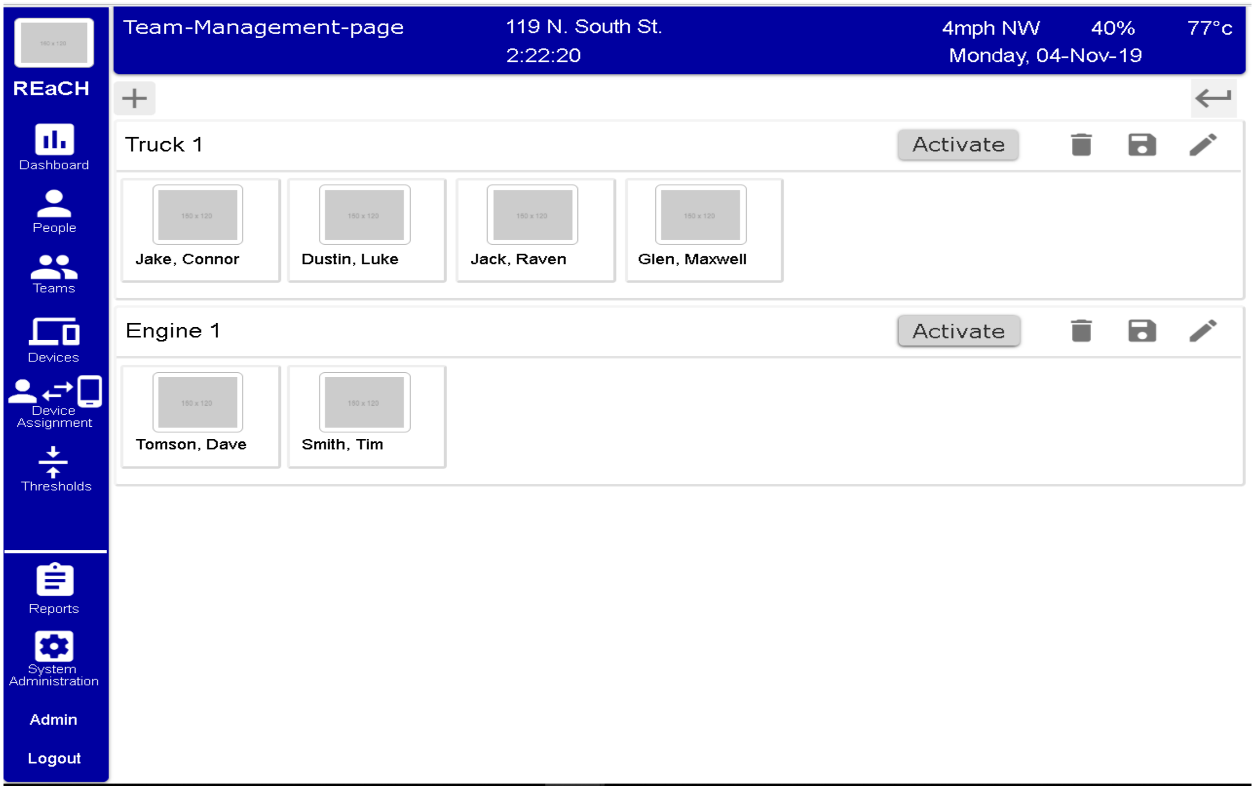

Special-Operation-People-page
119 N. South St.
2:22:20
4mph NW
40%
77°c
Monday, 04-Nov-19
REaCH
Dashboard
People
Teams
Devices
Device Assignment
Thresholds
Reports
System Administration
Admin
Logout
Photo
*First Name
*Last Name
Team Name
*Role
Last Active
Elapsed Time
Threshold Values
HR
HI
BP
RR
SpO2
Actions
Tomson
Dave
Truck 1
FR
10-18-2019 10:00:02
03:05:00 hours
Smith
Tim
TL
02:10:25 hours
N/A
Adam
Herald
Engine 1
04:15:15 hours
Olsen
Benito
Truck 2
01:45:12 hours
Church
Carl
05:20:06 hours
upload image
Nelson
Jade
01:45:45 hours
Remove Person
Are you sure, you want to remove the person?
Remove
Cancel

Team's Page

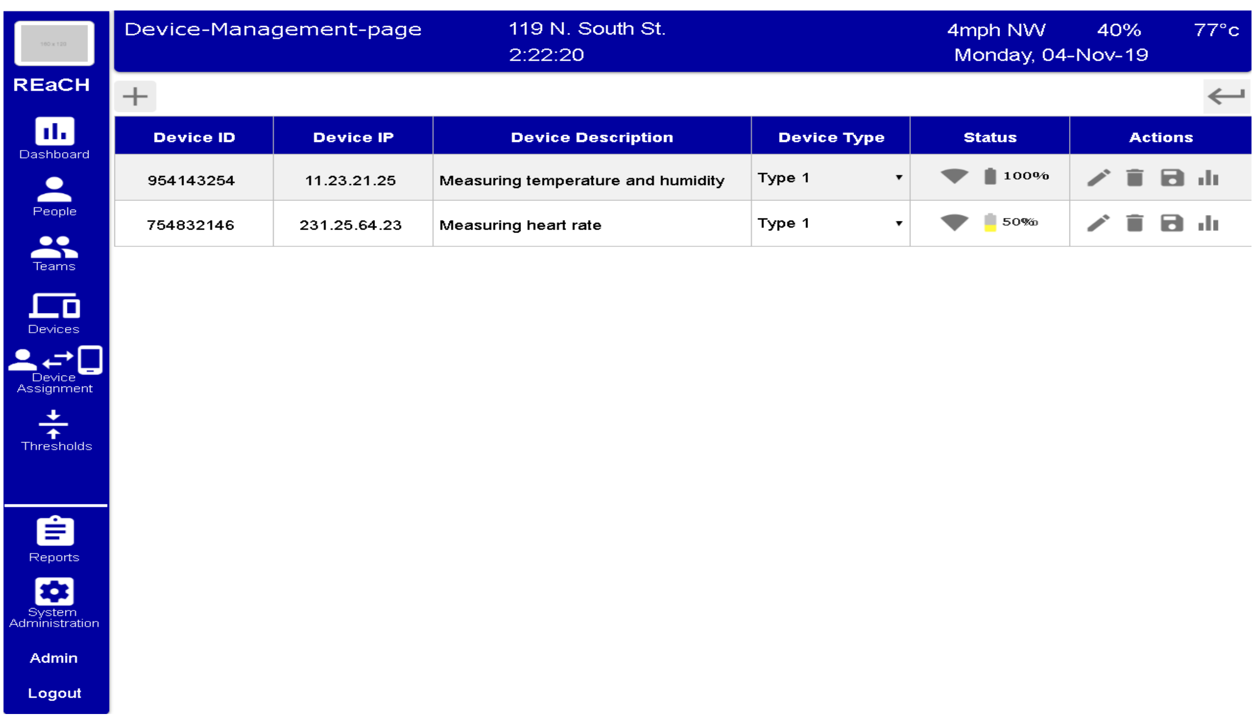

Team-Management-page
119 N. South St.
2:22:20
4mph NW
40%
77°c
Monday, 04-Nov-19
REaCH
Dashboard
People
Teams
Devices
Device Assignment
Thresholds
Reports
System Administration
Admin
Logout
Truck 1
Activate
Jake, Connor
Dustin, Luke
Jack, Raven
Glen, Maxwell

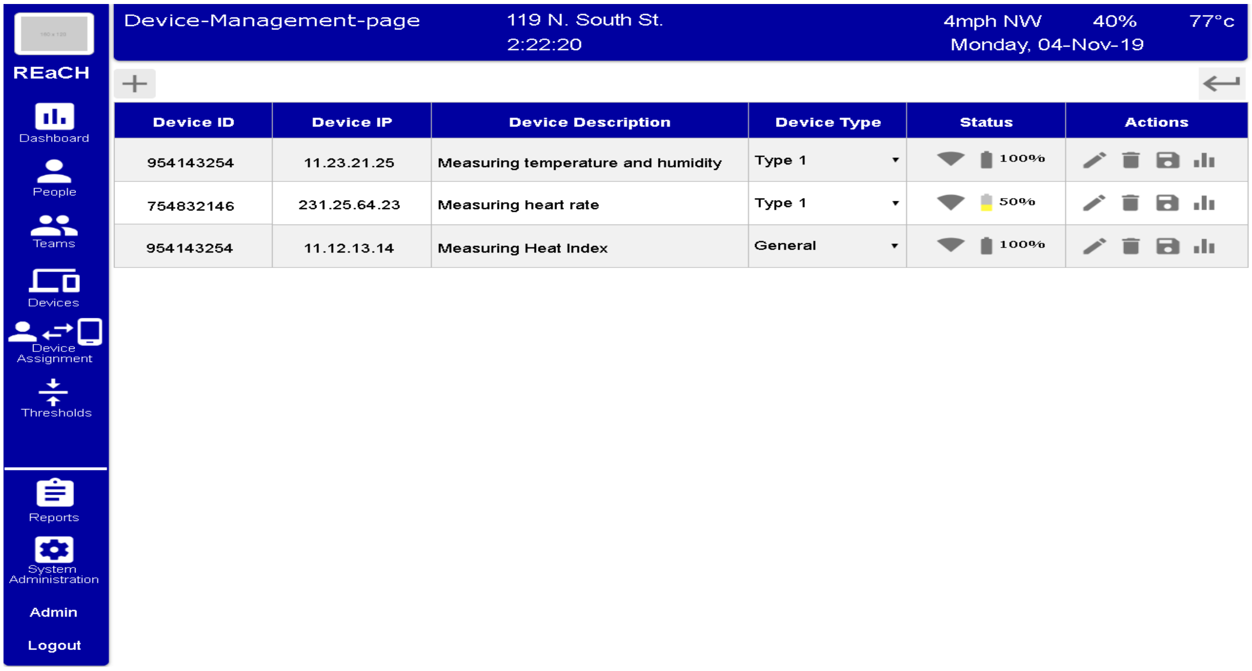

Team-Management-page
119 N. South St.
2:22:20
4mph NW
40%
77°c
Monday, 04-Nov-19
REaCH
Dashboard
People
Teams
Devices
Device Assignment
Thresholds
Reports
System Administration
Admin
Logout
Truck 1
Activate
Jake, Connor
Dustin, Luke
Jack, Raven
Glen, Maxwell
Enter Team Name
Activate
Available Member List
Add Team Member
Tang, Luna
May, Rehan
Bate, Jaxon
Church, Carl
Olsen, Benito
Adams, Herold
Smith, Tim
Tomson, Dave

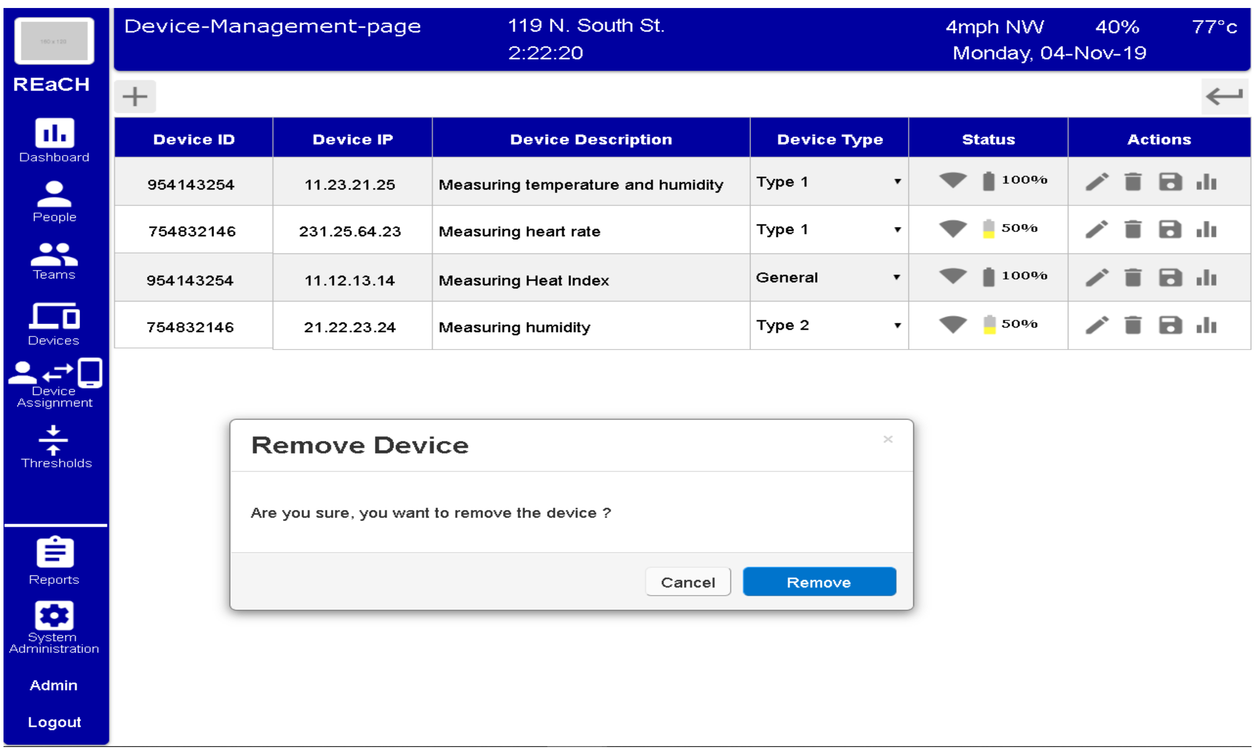

Team-Management-page
119 N. South St.
2:22:20
4mph NW
40%
77°c
Monday, 04-Nov-19
REaCH
Dashboard
People
Teams
Devices
Device Assignment
Thresholds
Reports
System Administration
Admin
Logout
Team 1
Activate
Jake, Connor
Dustin, Luke
Jack, Raven
Glen, Maxwell
Enter Team Name
Activate
Available Member List
Add Team Member
Tang, Luna
May, Rehan
Bate, Jaxon
Church, Carl
Olsen, Benito
Adams, Herold
Tomson, Dave
Smith, Tim


REaCH
Dashboard
People
Teams
Devices
Device Assignment
Thresholds
Reports
System Administration
Admin
Logout
Team-Management-page
119 N. South St.
2:22:20
4mph NW
40%
77°c
Monday, 04-Nov-19
Truck 1
Activate
Jake, Connor
Dustin, Luke
Jack, Raven
Glen, Maxwell
Engine 1
Activate
Tomson, Dave
Smith, Tim

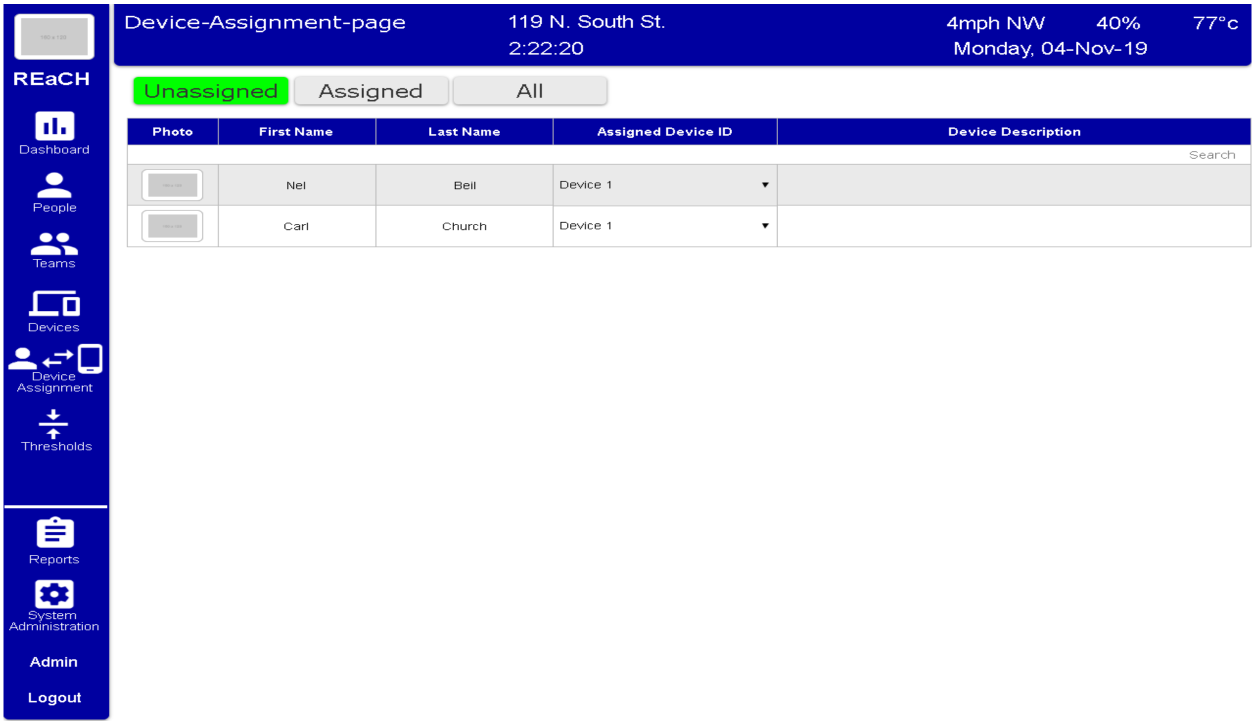
Device Page

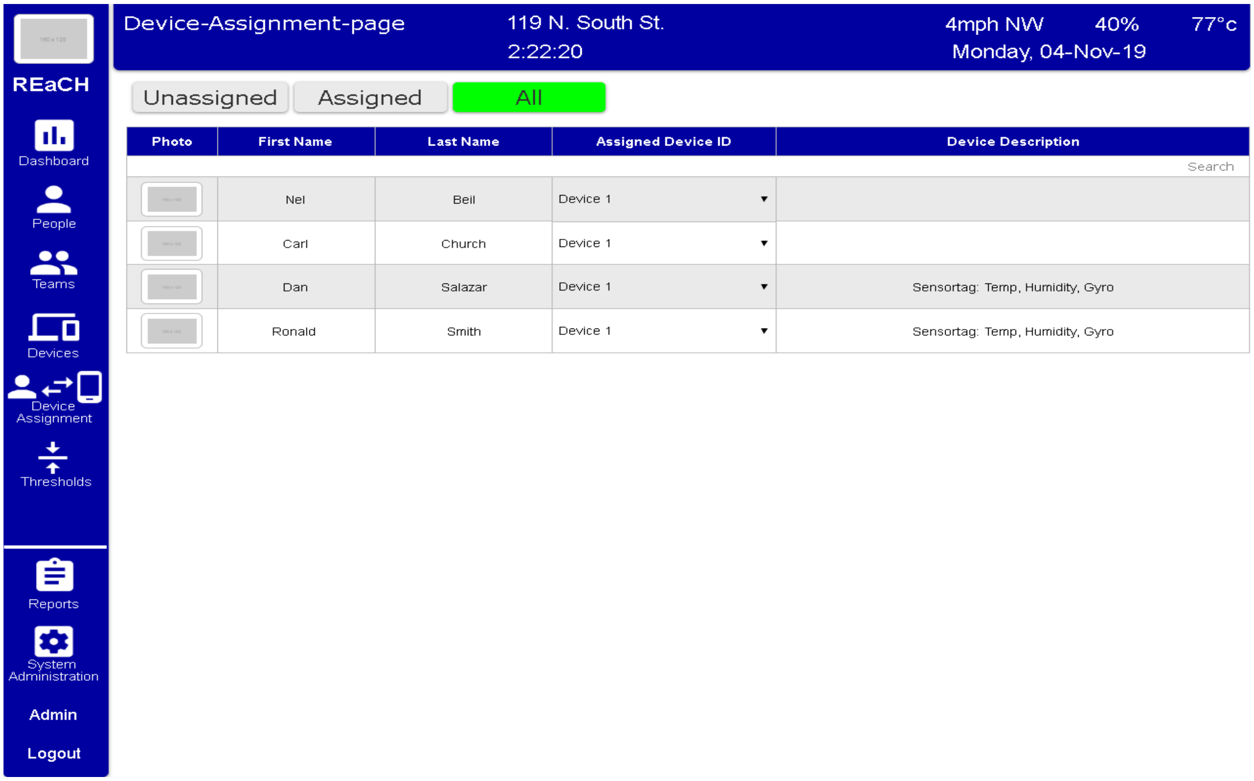

REaCH
Dashboard
People
Teams
Devices
Device Assignment
Thresholds
Reports
System Administration
Admin
Logout
Device-Management-page
119 N. South St.
2:22:20
4mph NW
40%
77°c
Monday, 04-Nov-19
Device ID
Device IP
Device Description
Device Type
Status
Actions
954143254
11.23.21.25
Measuring temperature and humidity
Type 1
100%
754832146
231.25.64.23
Measuring heart rate
Type 1
50%


REaCH
Dashboard
People
Teams
Devices
Device Assignment
Thresholds
Reports
System Administration
Admin
Logout
Device-Management-page
119 N. South St.
2:22:20
4mph NW
40%
77°c
Monday, 04-Nov-19
Device ID
Device IP
Device Description
Device Type
Status
Actions
954143254
11.23.21.25
Measuring temperature and humidity
Type 1
100%
754832146
231.25.64.23
Measuring heart rate
Type 1
50%
954143254
11.12.13.14
Measuring Heat Index
General
100%

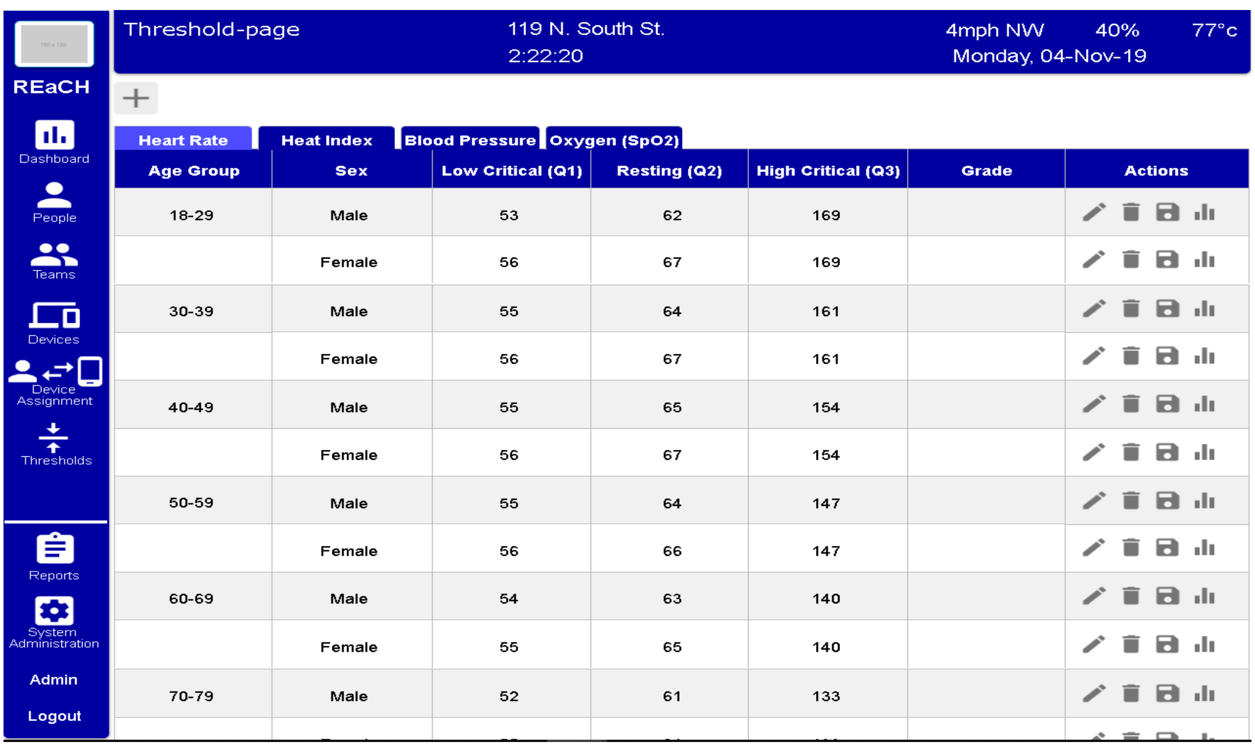

REaCH
Dashboard
People
Teams
Devices
Device Assignment
Thresholds
Reports
System Administration
Admin
Logout
Device-Management-page
119 N. South St.
2:22:20
4mph NW
40%
77°c
Monday, 04-Nov-19
Device ID
Device IP
Device Description
Device Type
Status
Actions
954143254
11.23.21.25
Measuring temperature and humidity
Type 1
100%
754832146
231.25.64.23
Measuring heart rate
Type 1
50%
954143254
11.12.13.14
Measuring Heat Index
General
100%
754832146
21.22.23.24
Measuring humidity
Type 2
50%
Remove Device
Are you sure, you want to remove the device ?
Cancel
Remove

Device -Assignment Page

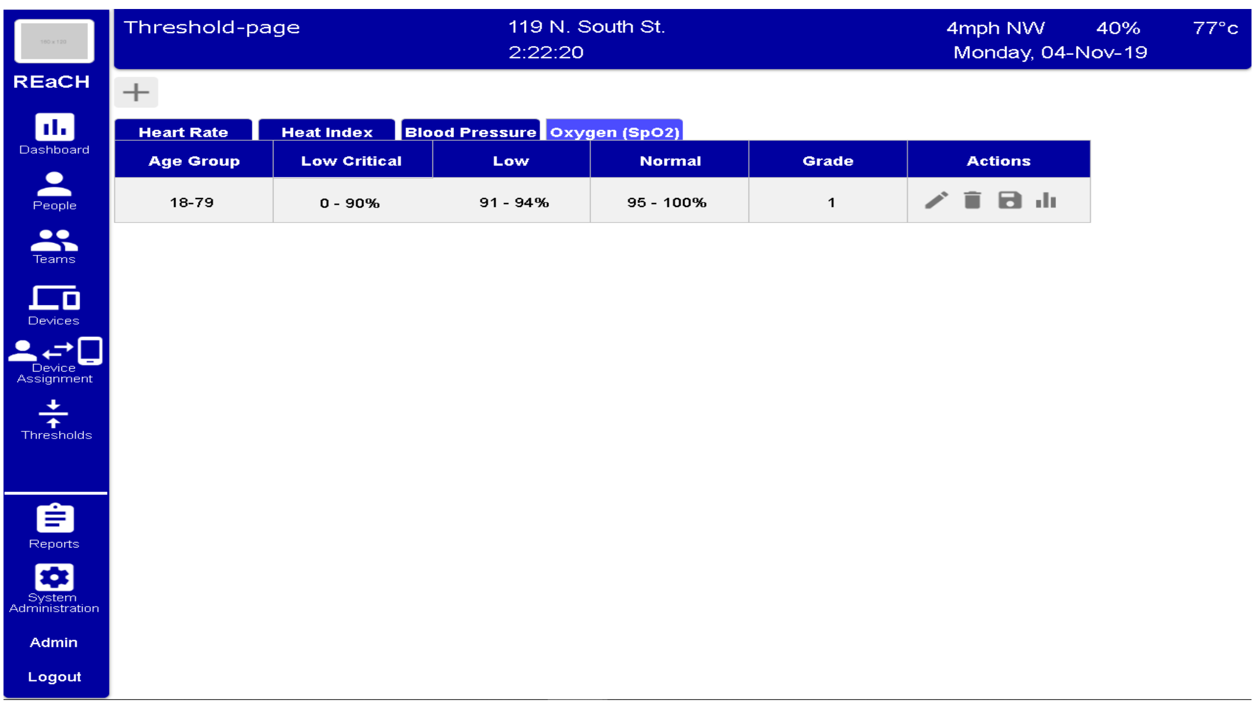




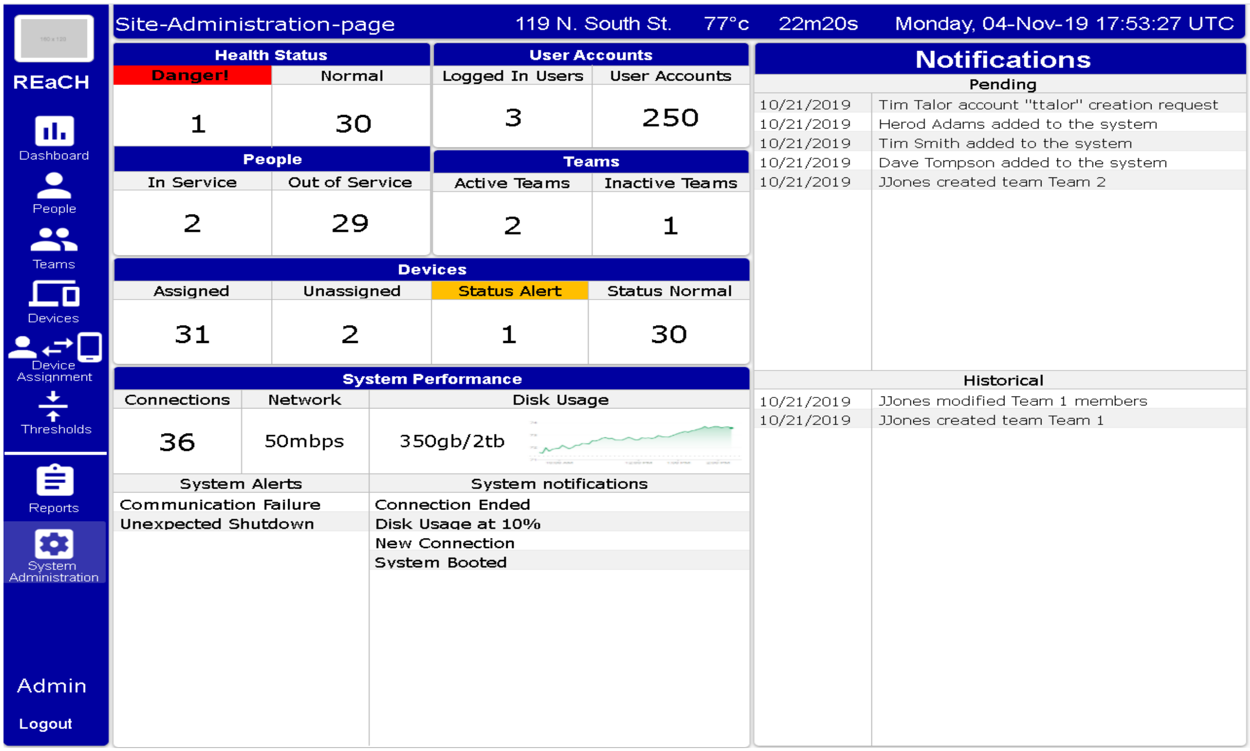
Threshold Page

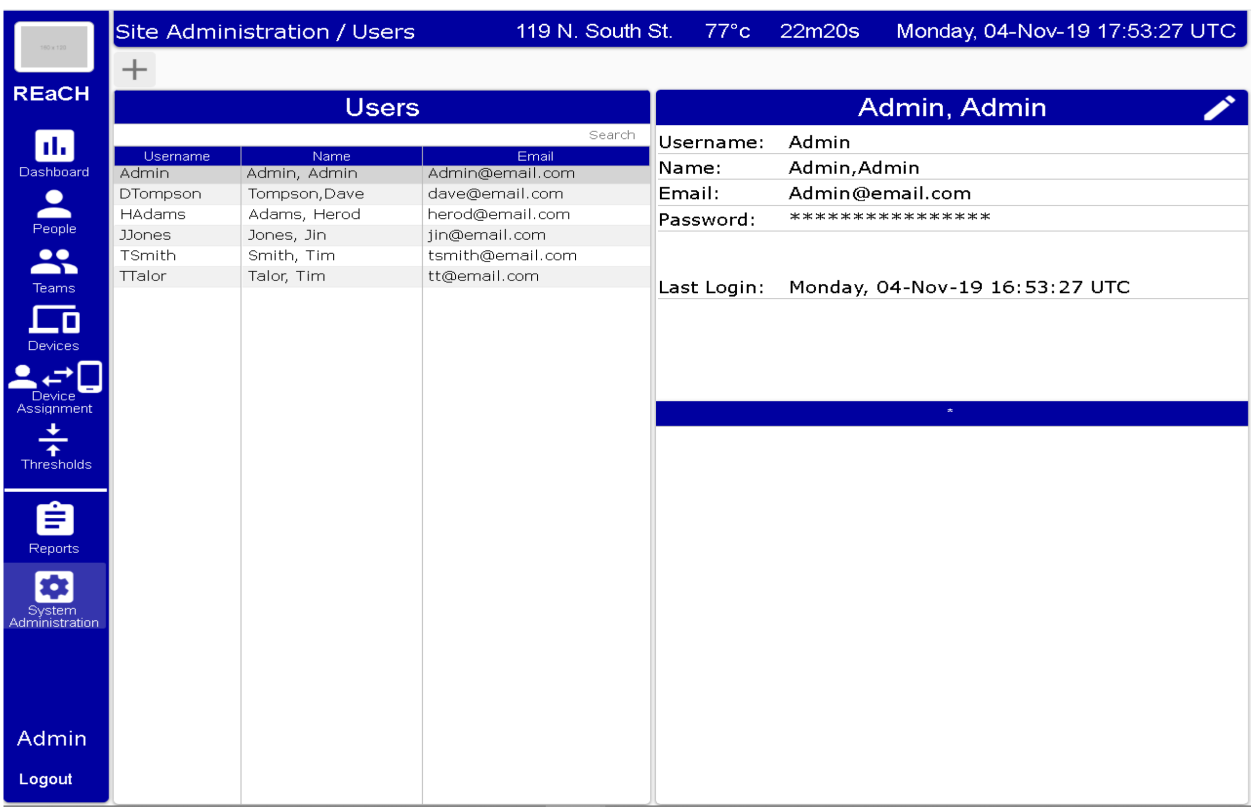



Threshold-page
119 N. South St.
2:22:20
4mph NW
40%
77°c
Monday, 04-Nov-19
REaCH
Dashboard
People
Teams
Devices
Device Assignment
Thresholds
Reports
System Administration
Admin
Logout
Heart Rate
Heat Index
Blood Pressure
Oxygen (SpO2)
Heat Index (inside suit)
Status
Grade
Actions
80 - 90
Caution
1
91 - 103
Extreme Caution
2
104 - 124
Danger
3
125 - 160
Extreme Danger
4


Threshold-page
119 N. South St.
2:22:20
4mph NW
40%
77°c
Monday, 04-Nov-19
REaCH
Dashboard
People
Teams
Devices
Device Assignment
Thresholds
Reports
System Administration
Admin
Logout
Heart Rate
Heat Index
Blood Pressure
Oxygen (SpO2)
Age Group
Low Critical
Low
Normal
Grade
Actions
18-79
0 - 90%
91 - 94%
95 - 100%
1

Site-Administration Page





Appendix G REaCH Technical Development Documentation

Table of Contents

1. Document Scope

The Scope of this document is to guide the developer to run the hazmat application in their local system. This document will illustrate the steps to install Postgres Database which we are going to use in our app. It covers all the command required to run the app in your local system. After completing the document, you will be able to successfully run the app.

2. Steps to Install and Create a PostgreSQL Database

Go to https://www.enterprisedb.com/downloads/postgres-postgresql-downloads to download the PostgreSQL for your system.

The version should be 10.11.

PostgreSQL Database Download

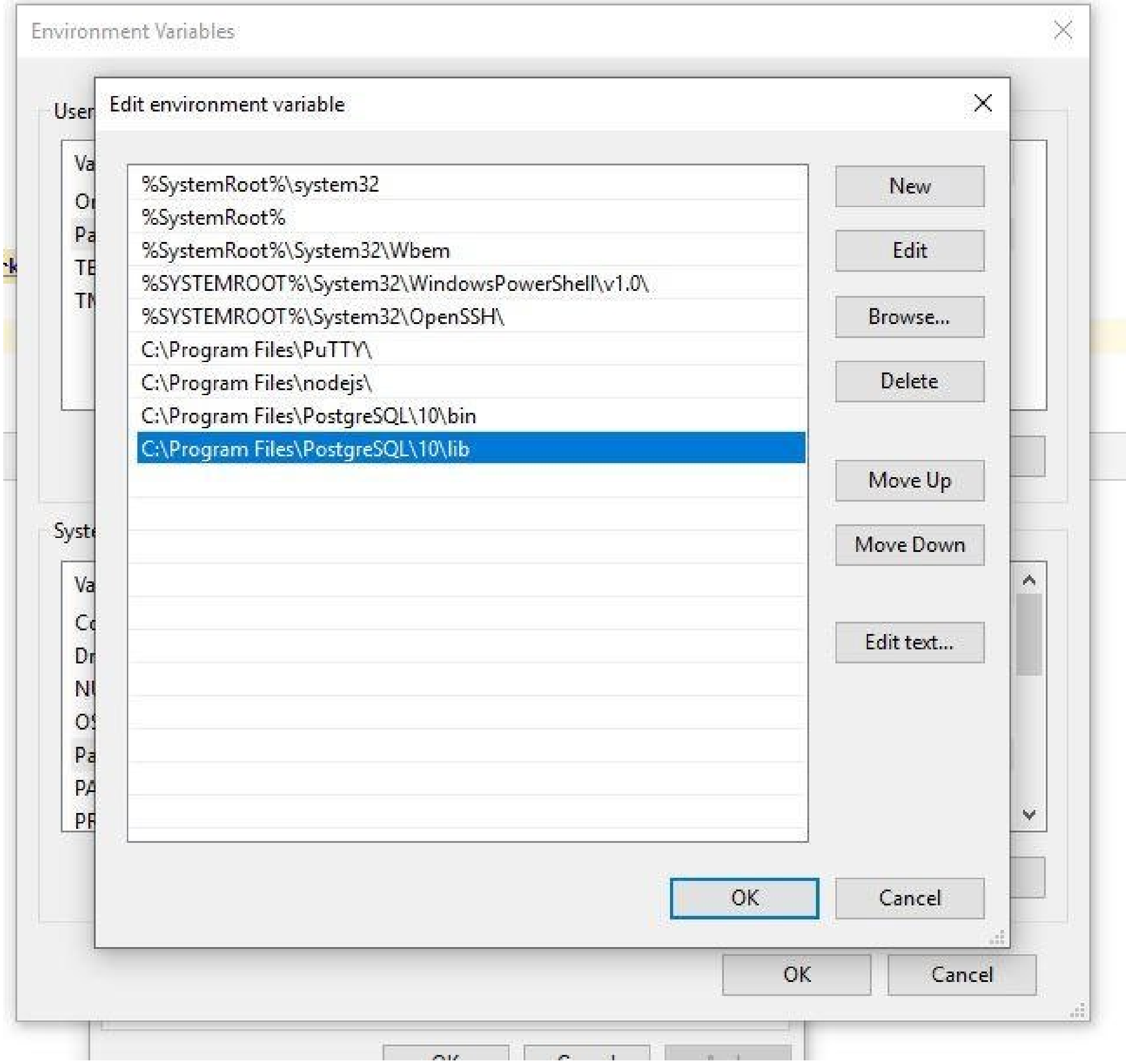
PostgreSQL Version	Linux x86-64	Linux x86-32	Mac OS X	Windows x86-64	Windows x86-32
12.1	N/A	N/A	Download	Download	N/A
11.6	N/A	N/A	Download	Download	N/A
10.11	Download	Download	Download	Download	Download
9.6.16	Download	Download	Download	Download	Download
9.5.20	Download	Download	Download	Download	Download
9.4.25	Download	Download	Download	Download	Download
9.3.25 (Not Supported)	Download	Download	Download	Download	Download

Please Note: EDB no longer provides Linux installers for PostgreSQL 11 and later versions, and users are encouraged to use the platform-native packages.
Version 10.x and below will be supported until their end of life. For more information, please see this blog post on Platform Native EDB Packages for Linux Users.

PostgreSQL 12.0 Installation Guide
PostgreSQL 12.0 Language Pack Guide

Note: For Mac you don't have to set the environment variable. But for windows, you will have to set the environment variable. So Please remember the path where you are installing your PostgreSQL.

Below shown two paths in the screenshots, you need to add in your environment variable after installing PostgreSQL.



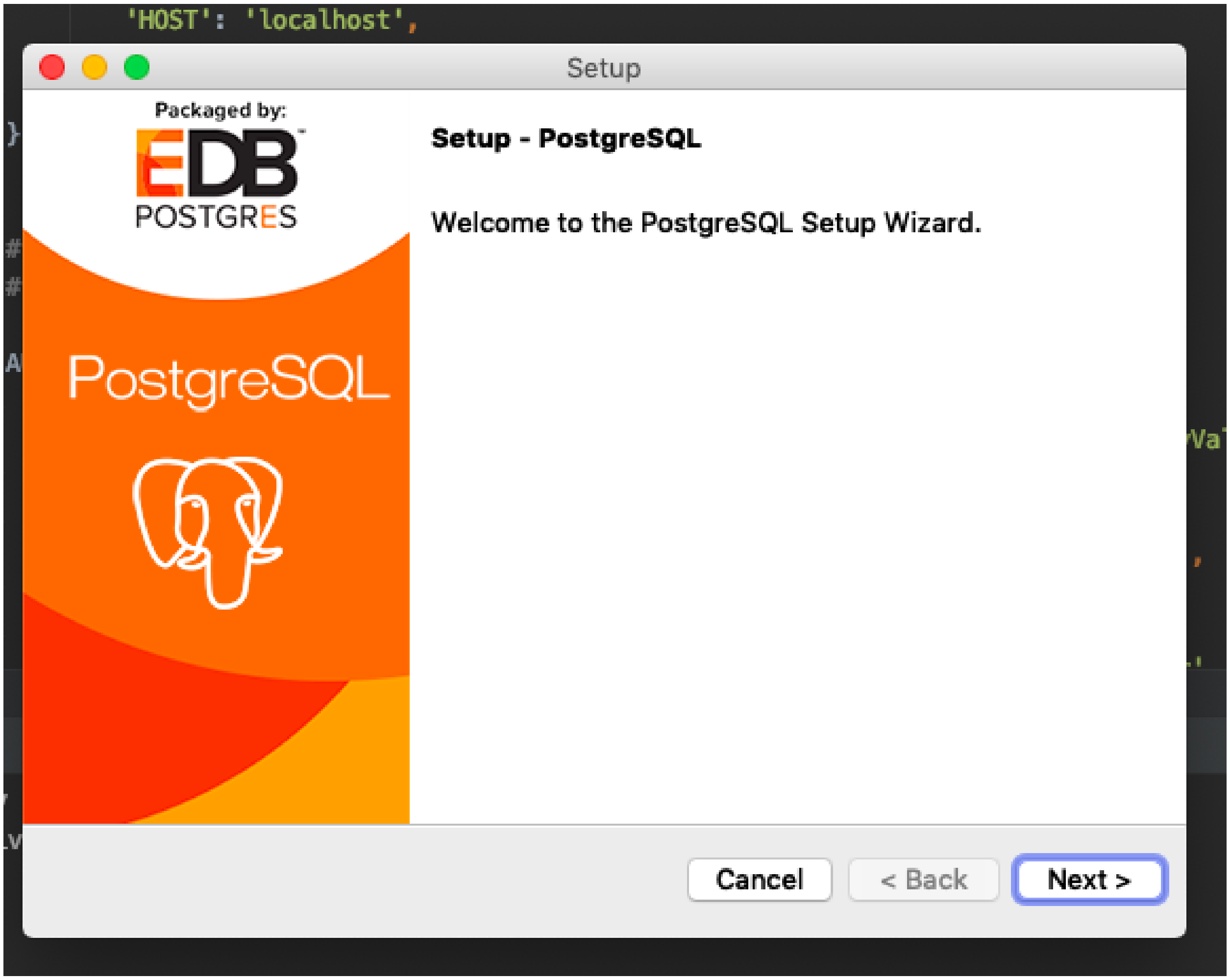
Remember the name and password of your database.

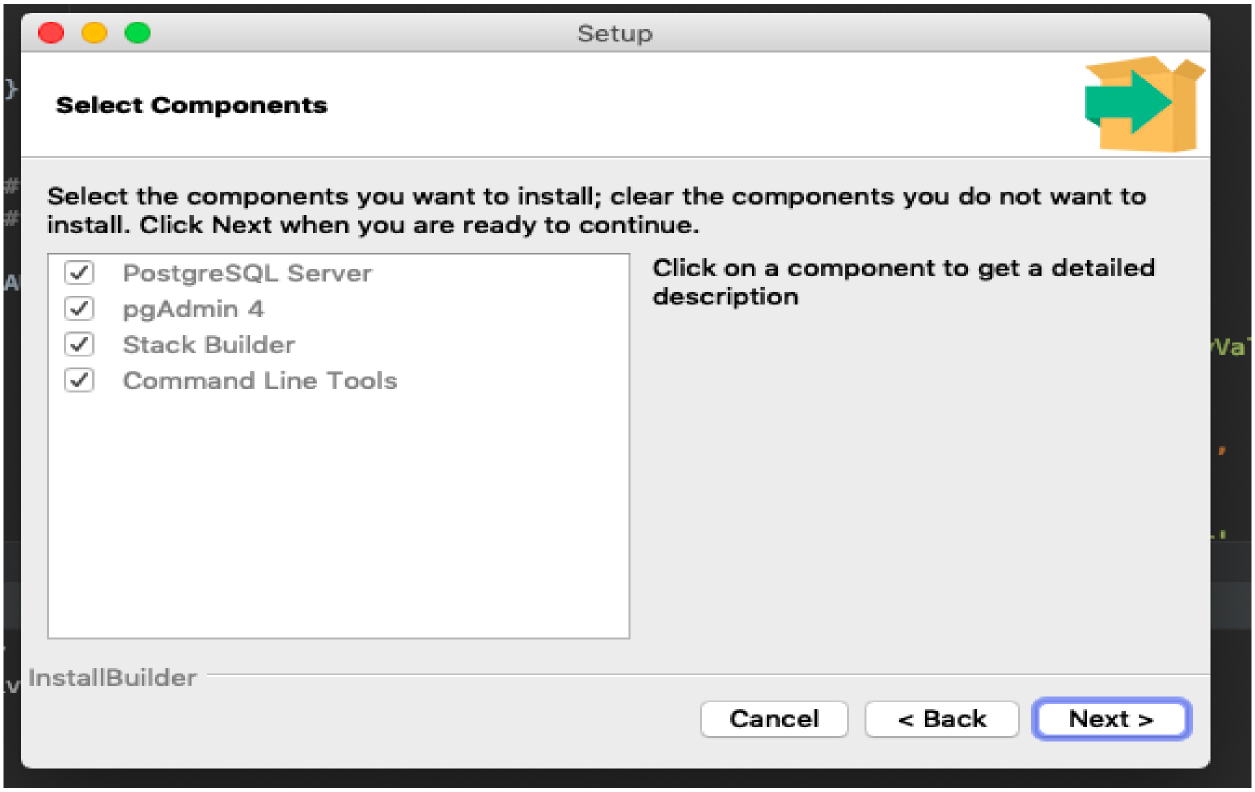
Download the version 10.11 (you can download the updated version as well)

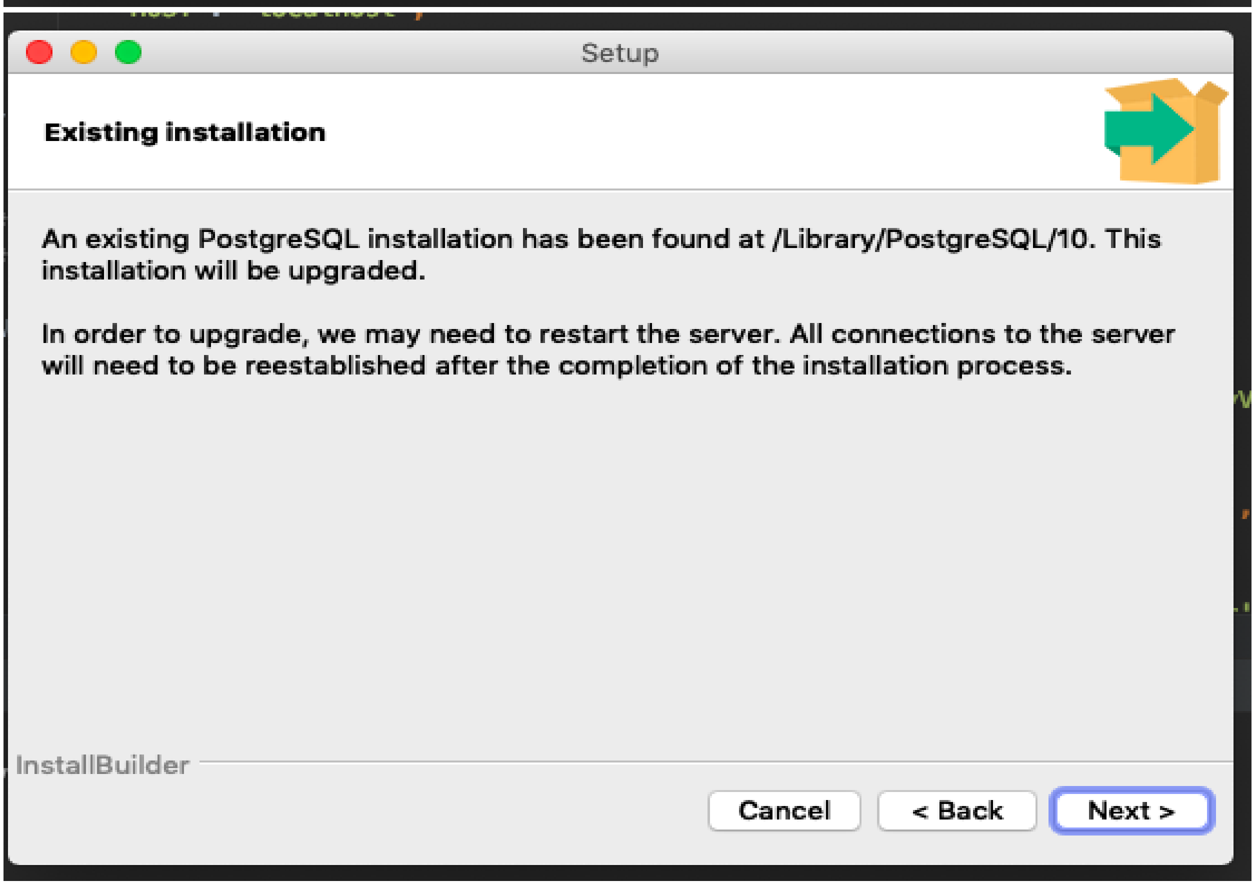
Keep everything default.

Keep the port number 5432

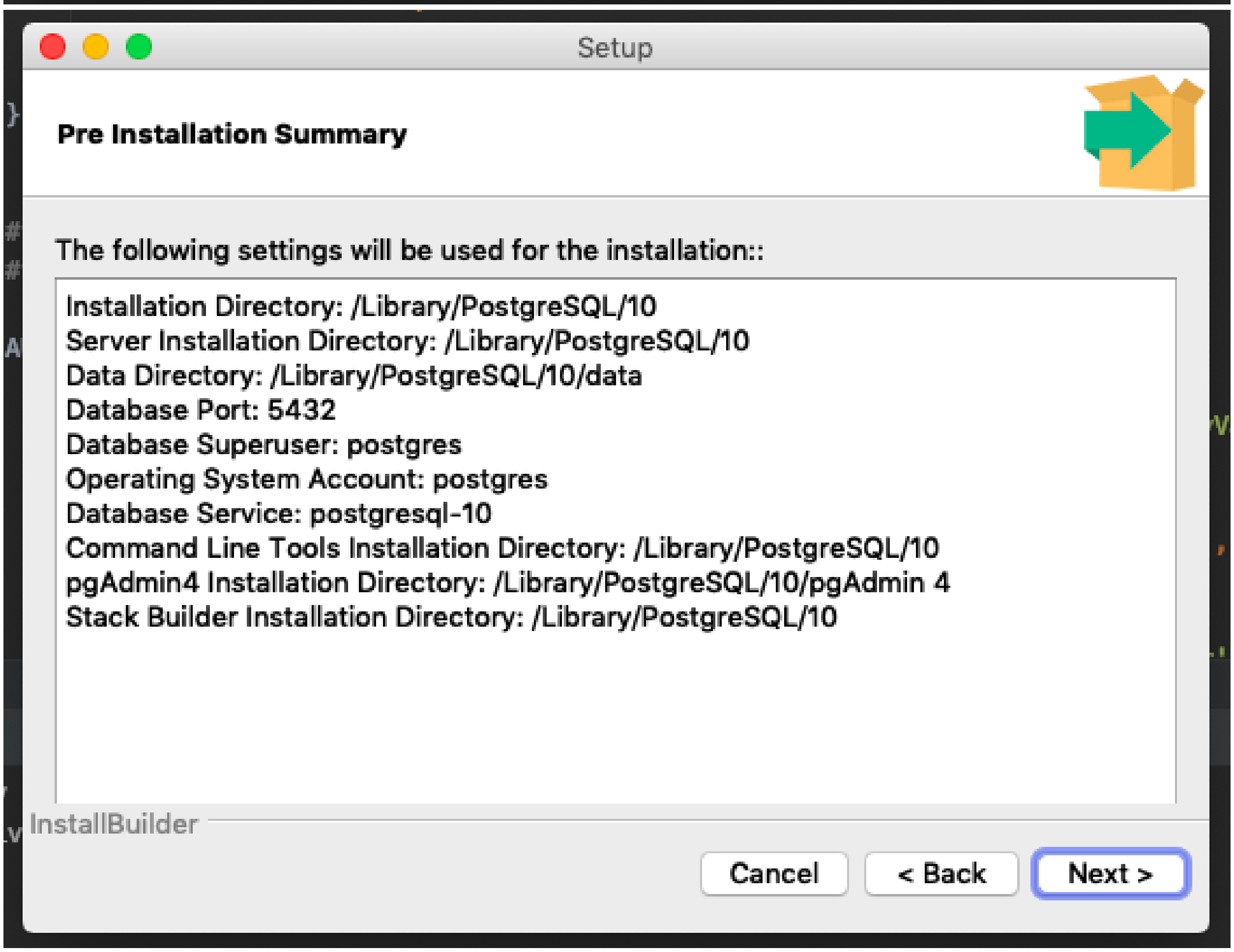
Follow the steps shown in images to install PostgreSQL 10.

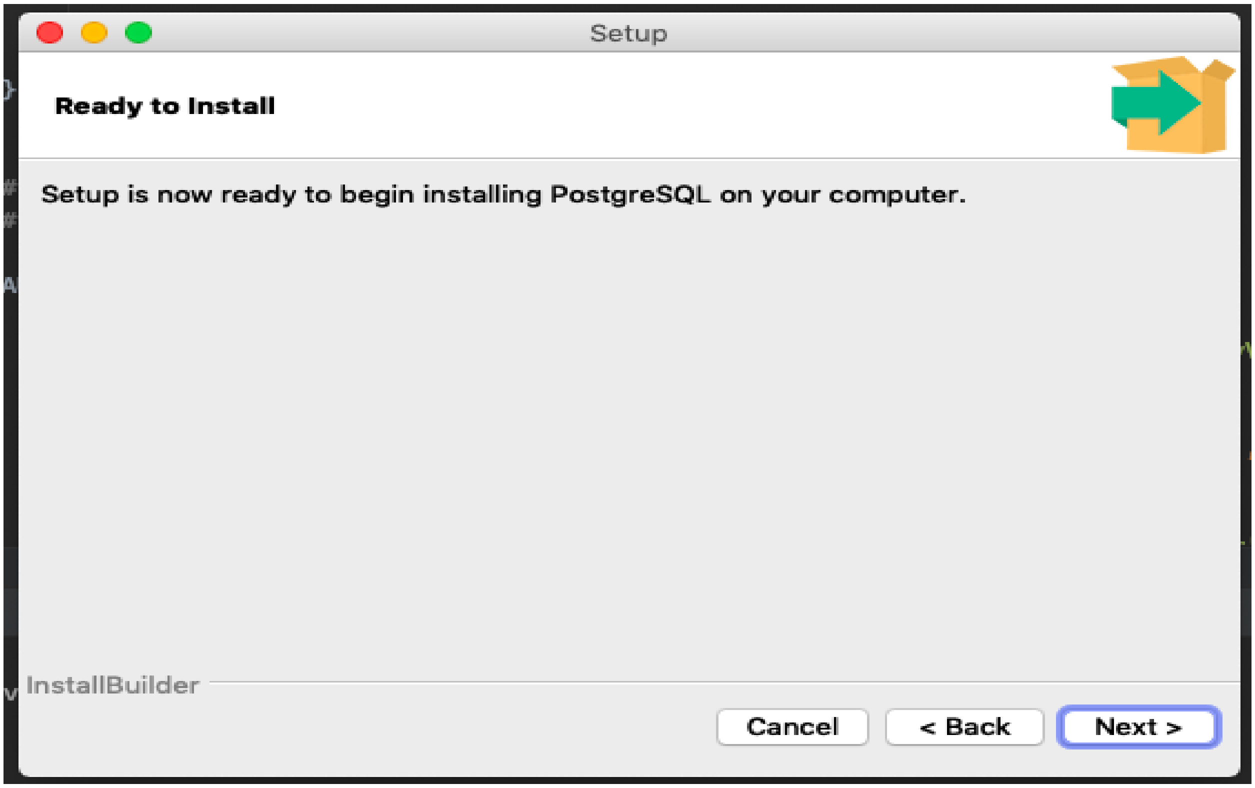

'HOST': 'localhost',
Setup
Packaged by:
EDB
POSTGRES
Setup - PostgreSQL
Welcome to the PostgreSQL Setup Wizard.
PostgreSQL
Cancel
< Back
Next >

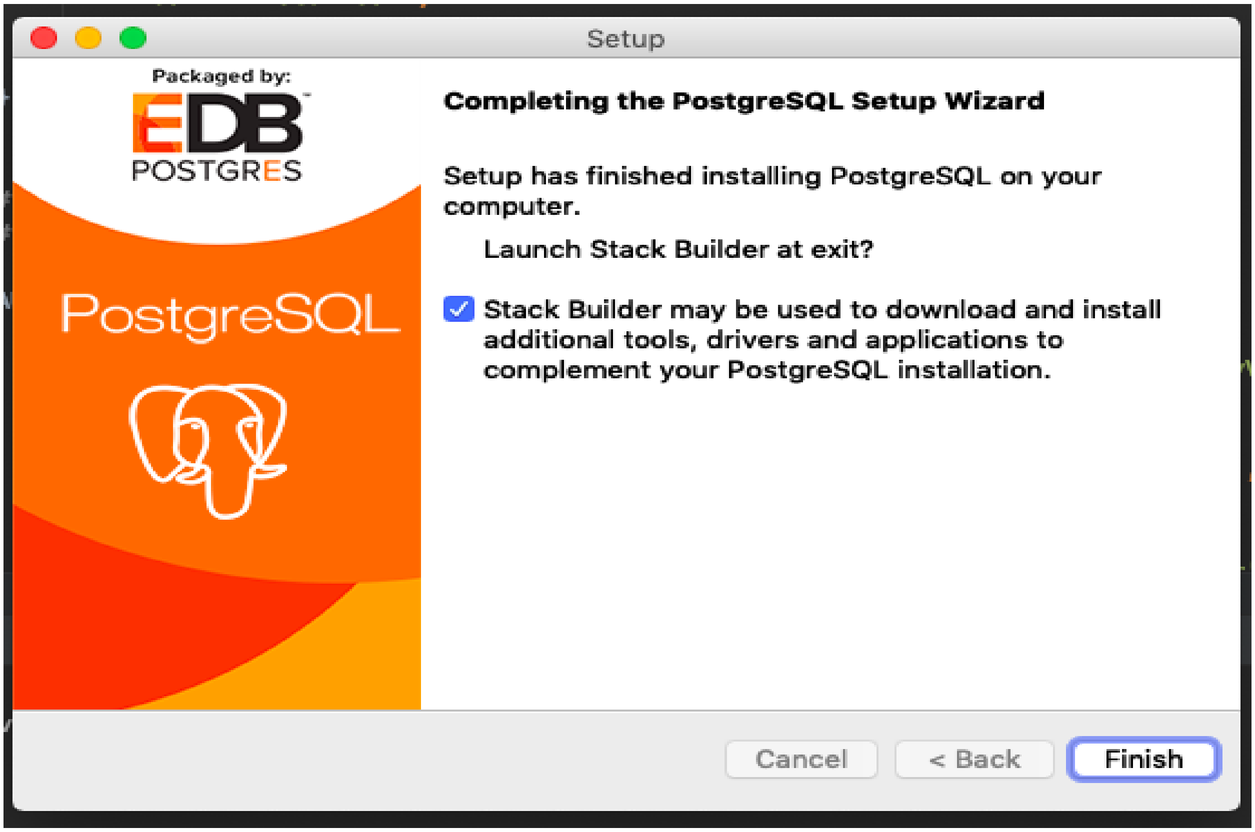

Setup
Select Components
Select the components you want to install; clear the components you do not want to install. Click Next when you are ready to continue.
PostgreSQL Server
pgAdmin 4
Stack Builder
Command Line Tools
Click on a component to get a detailed description
InstallBuilder
Cancel
< Back
Next >


Setup
Existing installation
An existing PostgreSQL installation has been found at /Library/PostgreSQL/10. This installation will be upgraded.
In order to upgrade, we may need to restart the server. All connections to the server will need to be reestablished after the completion of the installation process.
InstallBuilder
Cancel
< Back
Next >

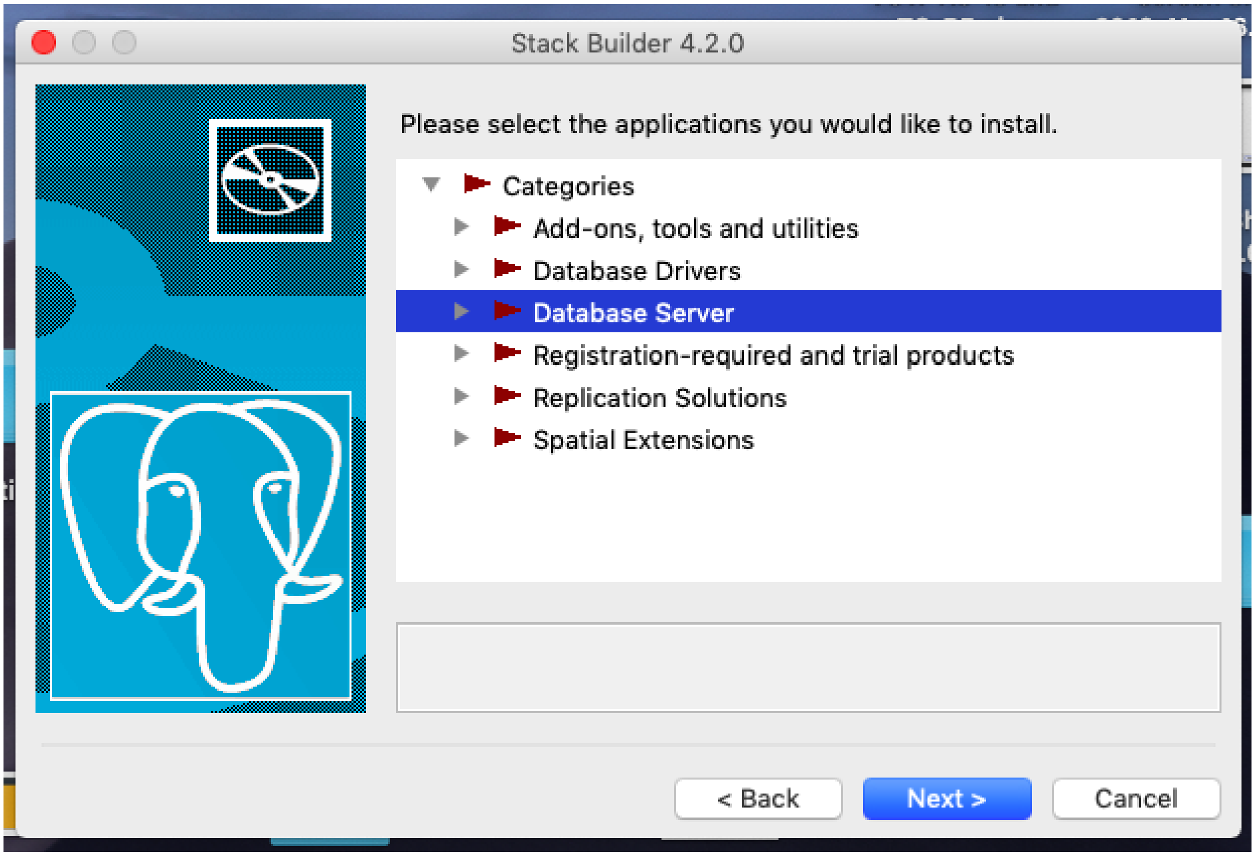

Setup
Existing data directory
An existing data directory has been found at /Library/PostgreSQL/10/data set to use port 5432. This directory and its configuration will be used for this installation.
InstallBuilder
Cancel
< Back
Next >

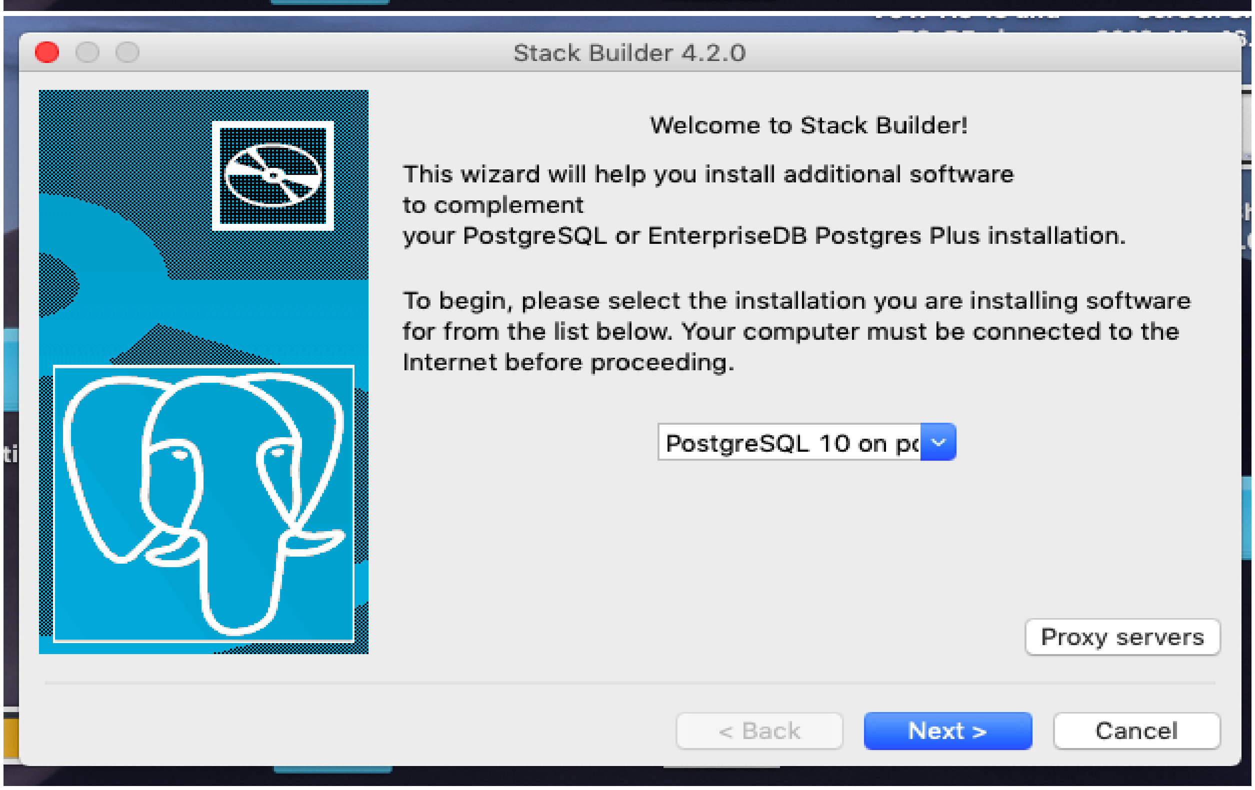

Setup
Pre Installation Summary
The following settings will be used for the installation::
Installation Directory: /Library/PostgreSQL/10
Server Installation Directory: /Library/PostgreSQL/10
Data Directory: /Library/PostgreSQL/10/data
Database Port: 5432
Database Superuser: postgres
Operating System Account: postgres
Database Service: postgresql-10
Command Line Tools Installation Directory: /Library/PostgreSQL/10
pgAdmin4 Installation Directory: /Library/PostgreSQL/10/pgAdmin 4
Stack Builder Installation Directory: /Library/PostgreSQL/10
InstallBuilder
Cancel
< Back
Next >

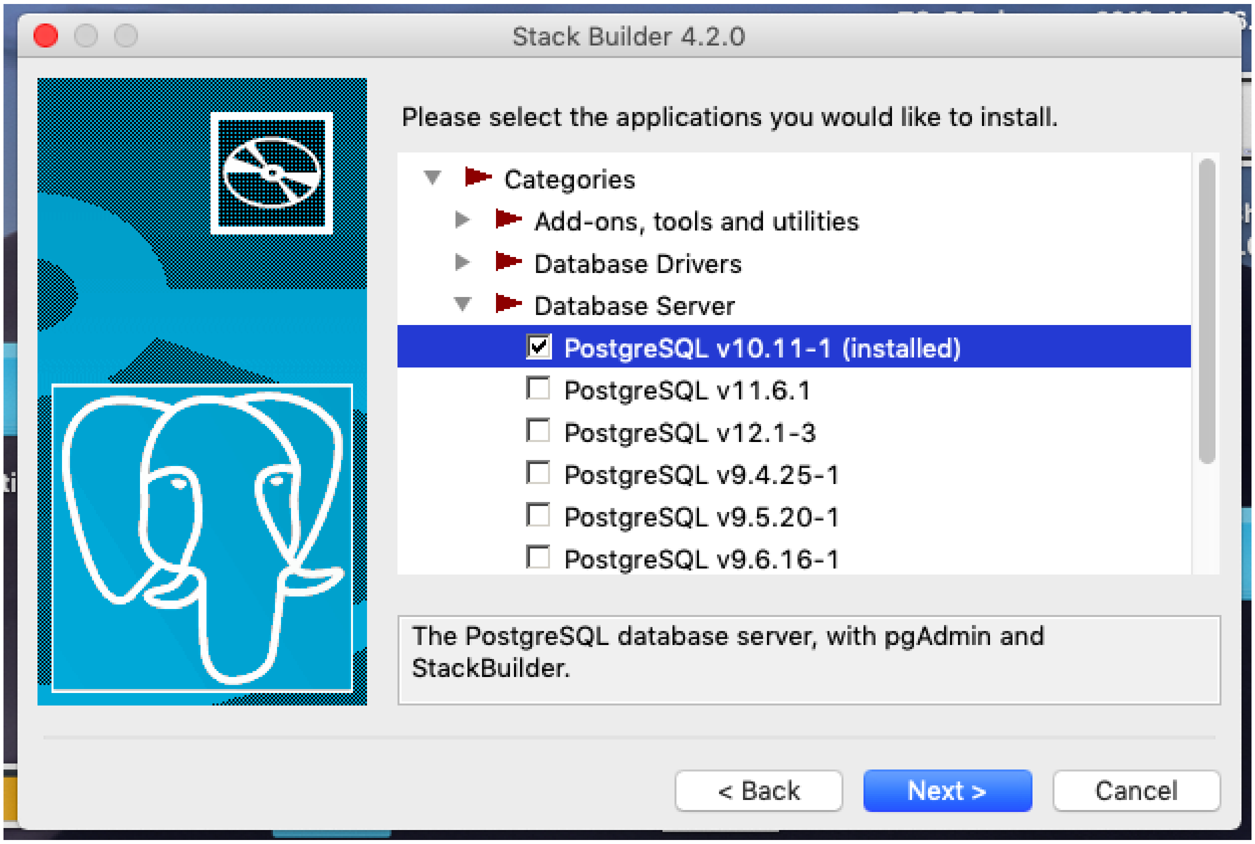

Setup
Ready to Install
Setup is now ready to begin installing PostgreSQL on your computer.
InstallBuilder
Cancel
< Back
Next >

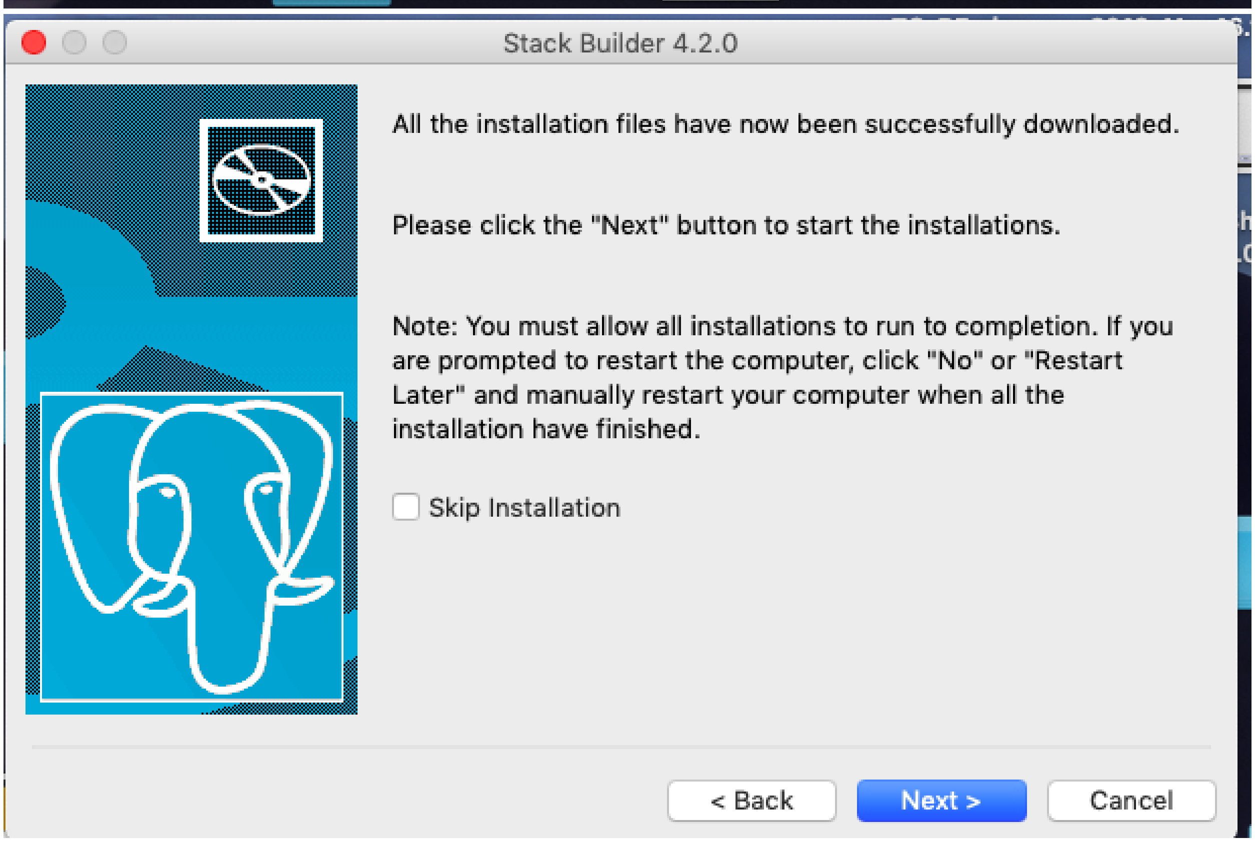

Setup
Packaged by:
EDB
POSTGRES
PostgreSQL
Completing the PostgreSQL Setup Wizard
Setup has finished installing PostgreSQL on your computer.
Launch Stack Builder at exit?
Stack Builder may be used to download and install additional tools, drivers and applications to complement your PostgreSQL installation.
Cancel
< Back
Finish

Now Launch Stack Builder. Select PostgreSQL 10 ..from the list

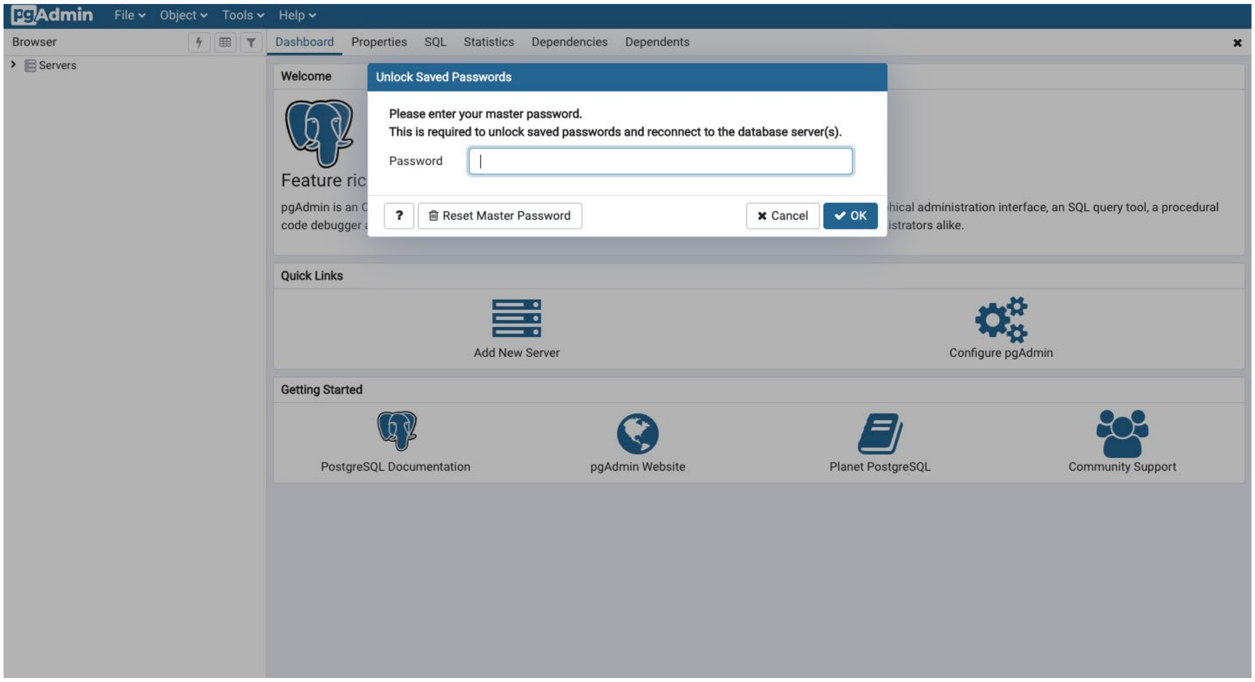




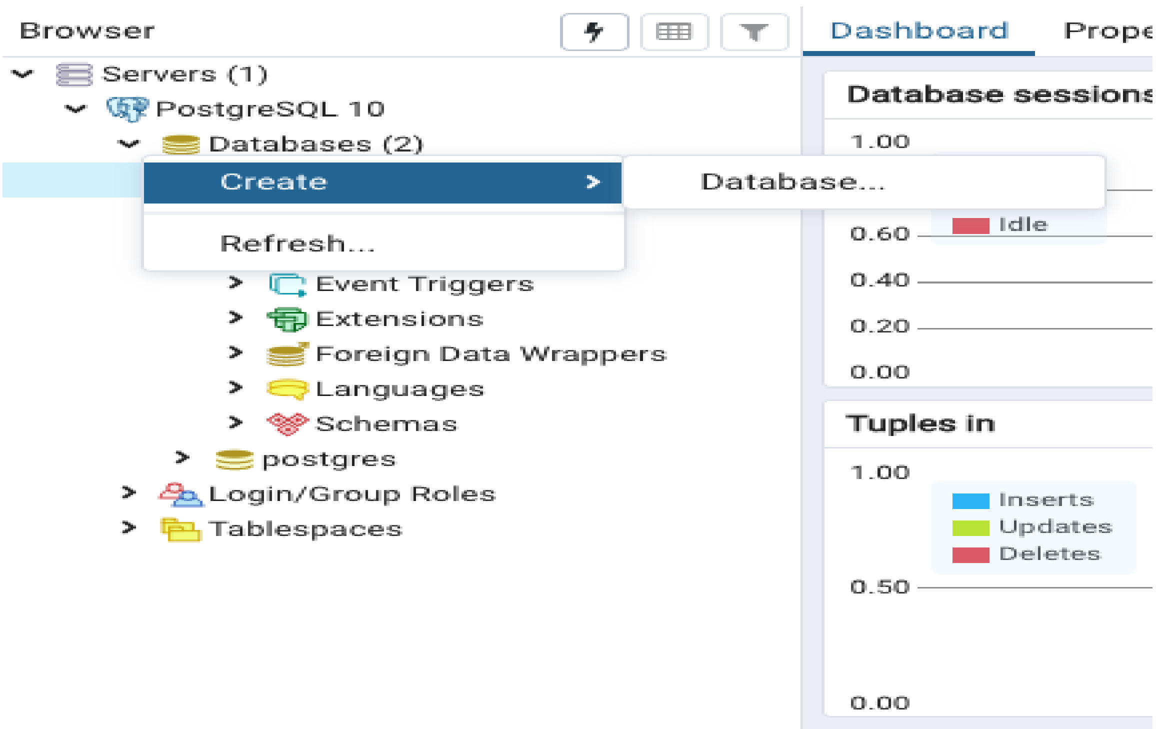

Stack Builder 4.2.0
Please select the applications you would like to install.
Categories
Add-ons, tools and utilities
Database Drivers
Database Server
PostgreSQL v10.11-1 (installed)
PostgreSQL v11.6.1
PostgreSQL v12.1-3
PostgreSQL v9.4.25-1
PostgreSQL v9.5.20-1
PostgreSQL v9.6.16-1
The PostgreSQL database server, with pgAdmin and StackBuilder.
< Back
Next >
Cancel


Stack Builder 4.2.0
All the installation files have now been successfully downloaded.
Please click the "Next" button to start the installations.
Note: You must allow all installations to run to completion. If you are prompted to restart the computer, click "No" or "Restart Later" and manually restart your computer when all the installation have finished.
Skip Installation
< Back
Next >
Cancel

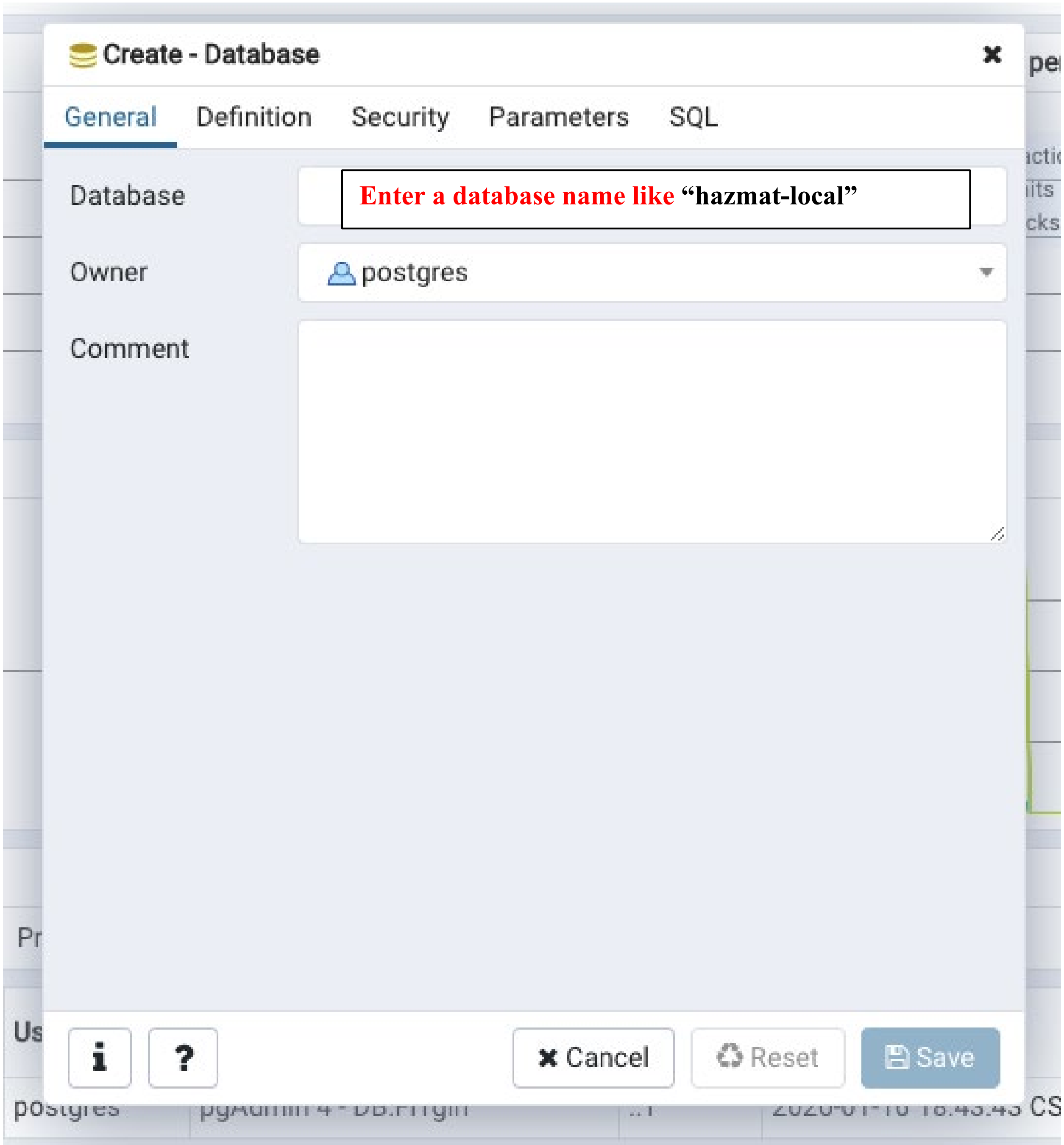
This will install pgAdmin4. Now launch pgAdmin4 from your system. Enter your system master password here.



Now click on Server Right click on PostgreSQL Click on create new Database.



Give a name to the database. Remember the name because you have to use it in your settings.py.



Hit "Save" after entering the name of database

3. Install Git Bash and Pycharm from the below link

GitBash is a terminal that we will use to write git commands and Pycharm is IDE which we will use for writing codes.

- **GitBash Download Link**: https://git-scm.com/downloads
- **Pycharm Download Link:** https://www.jetbrains.com/pycharm/download/#section=mac
- **Python Download Link (Version 3.**8.3): https://www.python.org/downloads/
- **Django Download & Installation Guide (Widows):** https://docs.djangoproject.com/en/3.0/howto/windows/#:~:text=To%20install%20Python%20on%20your,then%20click%20%E2%80%9CInstall%20Now%E2%80%9D.

4. Steps to Clone and Run the app in your Local Machine

Assumption

Assuming you have access to Reach Git Repository. This section contains technical information for running the complete app in your local system. We are also assuming that you have created a PostgreSQL database for your local. (Click here or go to step 2 to create PostgreSQL database) and also have installed PyCharm.

Step 1

Login to your git repository and go to uno-public-health-informatics-lab/REACH repository.

Open terminal/Git Bash (to download Git Bash Click here) in your System and go to the desired path where you want to keep the folder of the project.

For development on this project, the development branch should be checked out from the GitHub.

Example: git clone -b development https://github.com/uno-public-health-informatics-lab/REACH.git

Clone the folder from GitHub using

git clone "url of the repository"

Or Download the folder on your PC

Once the project folder is cloned or downloaded in your System.

Open the downloaded project folder using Pycharm or Visual Code

<u>Step 2</u>

Now we need to create a virtual environment to run the app.

We need to follow step 2, step 3 and step 4 for this.

Install Virtual Environment

On macOS and Linux:

```
python3 -m pip install --user virtualenv
```

On Windows:

```
py -m pip install --user virtualenv
```

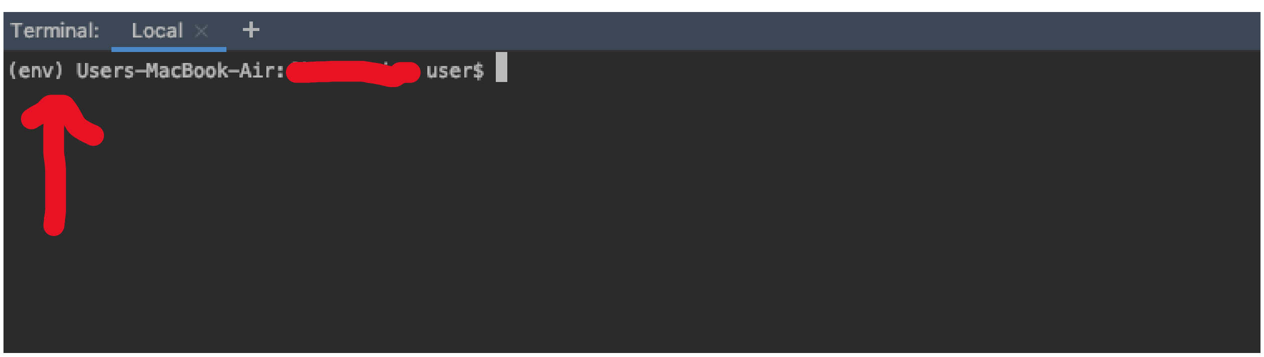
Step 3

Create a Virtual Environment
On macOS and Linux:
`python3 -m venv env`
On Windows:
`py -m venv env`

Step 4

Activate your Virtual Environment
On macOS and Linux:
`source env/bin/activate`
On Windows:
`.\env\Scripts\activate`

Now you have your virtual environment activated. This you can confirm by seeing an '(env)' prefix before your project folder path.



Step 5

From PyCharm click on **hazmat settings.py.**

Note: After cloning the code from Github, you always need to change the Database credentials to local database credentials and while pushing it back to github, again you have to change the database credential to heroku postgres credentials. So, it will be better if you keep a copy of both settings.py handy and replace the settings.py as required.

Steps

Inside settings.py change the database name and password with your local Postgres SQL database name and password. Keep the rest same as shown in picture below.

Note: When you are working in your local keep the Host as localhost and User as postgres as shown below.

```
# # ## Local Setting
DATABASES = {
    'default': {
        'ENGINE': 'django.db.backends.postgresql',
        'NAME': 'Enter you local postgres database name',
        'USER': 'postgres',
        'PASSWORD': 'Enter your local postgres database password',
        'HOST': 'localhost',
        'PORT': '5432',
    }
}
# Password validation
# https://docs.djangoproject.com/en/2.0/ref/settings/#auth-password-validators

AUTH_PASSWORD_VALIDATORS = [
    {
        'NAME': 'django.contrib.auth.password_validation.UserAttributeSimilarityValidator',
    },
    {
        'NAME': 'django.contrib.auth.password_validation.MinimumLengthValidator',
    },
    {
        'NAME': 'django.contrib.auth.password_validation.CommonPasswordValidator',
    },
    {
        'NAME': 'django.contrib.auth.password_validation.NumericPasswordValidator',
    },
]
```

Step 6

Now we need to install some dependency and packages that is required to build and run the app.

Install All requirements **pip install -r requirements.txt**

This command will install all the packages mentioned in requirements.txt file of your project.

<u>Step 6</u>

To create Schema, Tables and rules of the Database Table for our app, we will use following two commands.

Generate database from the code using **python manage.py makemigrations** **python manage.py migrate**

<u>Step 7</u>

Navigate to the Hazmat-client location in the terminal and run the command "npm install" to download the package and its dependencies and run "ng build" for compiling the application.

<u>Step 8</u>

Navigate back to the reach app in the terminal. Now we need to create a superuser/admin login id and password to login. Below command will create Username and password for admin account.

Create Superuser **python manage.py createsuperuser**

<u>Step 9</u>

Now we are ready to run the app in our local server 127.0.0.1:8000. Below command will run the app in local server.

Run localserver **python manage.py runserver**

5. Steps to connect PostgreSQL Database to PgAdmin4

This section assumes that you have PgAdmin4 install in your system. This section will guide a developer to connect PostgreSQL Database to PgAdmin4.

Click here to see the steps

6. Definitions of Packages used at requirements.txt for Building the App

- **Django-Rest-Framework:** https://pypi.org/project/djangorestframework/
- **Beautifulsoup4:** https://pypi.org/project/beautifulsoup4/
- **Dj-Database-url:** https://pypi.org/project/dj-database-url/
- **Django-Bootstrap4:** https://pypi.org/project/django-bootstrap4/
- **Django-Crispy-Forms**: https://pypi.org/project/django-crispy-forms/
- **Psycopg2:** https://pypi.org/project/psycopg2/
- **Whitenoise:** https://pypi.org/project/whitenoise/